Labor Productivity: Un Tour d'Horizon

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Many official and unofficial statements by the World Bank and its staff have stressed that raising the productivity of the poor must be a central part of any effective strategy to promote economic development and eliminate absolute poverty, and much of its research focusses directly or indirectly on policy measures that might help to accomplish this. An important part of this paper is a survey of the state of knowledge and research about links between human development and labor productivity. It emphasises particularly health and nutrition, since there have been several recent Bank surveys of issues relating to education and productivity. This part of the paper served as a Background Note for the World Development Report, 1980. Where possible, the paper focusses on the determinants of physical productivity rather than earnings, which would have involved discussions of labor markets, aggregate demand etc.

Research into the relationship between human development (however broadly defined) and productivity is only a small part of the research which has focussed on the determinants of labor productivity. This stretches from cross-national comparisons of the sources of aggregate output on the one hand to research on industrial relations, ergonomics (known in the US as human engineering), and social and experimental psychology at the other. Obviously it has not been possible to survey those fields in any depth, and in some areas this paper can only hope to be a guide map to other surveys. But we believe that it would be helpful to the Bank and others in designing further research on productivity to have a broader sense of the whole field. Since the determinants of labor productivity are so complex and multifaceted, virtually all studies can consider only a few of them; it is useful to have some idea of what one is leaving out. Some of the most interesting research has been done on productivity in developed countries with few parallels in developing countries. Since this might be suggestive of future research on developing countries we have included it in the survey.

The paper draws certain conclusions for future research. We believe that relatively little is likely to be learnt from further cross-national aggregate comparisons. Much more, however, might be learnt from looking at the determinants of productivity across similar industries in different countries, and especially among matched firms and processes. In this direction, the most suggestive research so far has tended to look at developed rather than developing countries, and could well be extended to the latter.
We are a very long way from having exhausted the possibilities of research into productivity at the level of individual workers. Research here has been bedevilled with problems arising from observer (Hawthorne) effects and from self-selection and adaptation. The mechanism by which a particular level of human resource development is expected to have an impact on productivity has often not been precisely specified, which can make it difficult both to interpret findings and to draw conclusions for policy.

Finally, the many studies in areas beyond the conventional boundaries of economics — ergonomics, industrial relations etc. — that have found the potential for major increases in productivity without significant additional human or physical investment serve as a reminder that the world is a very inefficient place and could get much more output from its productive resources. Getting prices right, and promoting competition, may help to alleviate the problem. But it is unlikely to be the whole answer. Whether there are any lessons for the Bank about policies that might be adopted, or even merely about research that should be undertaken, are questions that we feel ill-equipped to answer. But they are worth more thought than they have so far received.

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Introduction

The productivity of labor is an economic concept of central importance. In the first place, output per head of the labor force is a major determinant of relative well-being among nations. Differences in demographic structure and in a variety of social, economic and cultural forces cause wide variation in the proportion of the population that is economically active, but not enough to invalidate this point. Second, the relative productivity of individuals within a society largely determines — for most individuals in most societies — relative incomes, not withstanding private ownership of assets, public efforts to redistribute incomes, and the many factors that can cause a divergence between productivity and earnings.

In spite of its significance, the concept of labor productivity remains highly elusive. The term itself is used in a number of ways. At one extreme, it may refer to the value of gross output per worker, or per man-hour. At the other extreme, a careful attempt may be made to measure the physical output of labor net of the contribution of other factors of production. Moreover it is obvious that the determinants of relative productivity — whether among nations or between neighbors at a factory bench — are themselves complex. While there may still be a heuristic purpose in simple economic models that make output a function of physical capital and labor, nobody would claim they were realistic.

At the very least, it is generally recognized that the quality of labor is of crucial importance. Some dimensions of this — in particular, education, training and experience — have been readily incorporated into conventional economic analysis. Sensible proxies for quality — e.g. years of schooling — can easily be found, and with knowledge of how earnings are affected by education and training, estimates, albeit controversial, of their contribution to productivity can be made. Health and nutritional status are other obvious dimensions of labor quality. Their productivity effects have been less studied than those of education, perhaps because they appear less important in determining productivity differentials — at least among developed countries, or among individuals in such countries, where so much research has taken place. There are also considerable difficulties in measuring health or nutrition 'status.' In addition the policy relevance of such research, at least in developed countries, is more doubtful than in the case of education, since the productivity consequences are not likely to be an important reason for public intervention to raise levels of health and nutrition.

An important purpose of this survey is to look broadly at research that has examined the effects of educational, health and nutritional status on labor productivity in developing countries. As such, it is intended to complement other World Bank survey papers considering the outcomes of education, in various respects, including its effects on productivity and incomes.
Casual observation, however, suggests that differences in human capital (including health and nutritional status) plus differences in physical capital, are not likely to be sufficient to explain productivity differences. Imagine a fully equipped factory run for a year with ample supplies of raw materials and a buoyant market. Imagine it staffed with Germans operating under typically German working conditions. Then imagine it operating under the same conditions but with British workers and run by British management. Most people would expect that the British factory would have a lower output than the German one, but also that the differences could not be traceable to education or health differences between German and British workers. In this hypothetical case, it is likely that differences in managerial practices, payment systems, trade union rules, and attitudes to work would prove very important. To use Leibenstein's concept, one might expect the degree of \( x \)-inefficiency', to be greater in the British case (Leibenstein, 1969). In consequence, studies of the determinants of productivity need to go well outside the conventional boundaries of economics. Relevant work includes psychological research into individual motivation, studies of organizational structures, managerial behavior and salary and wage systems, and ergonomic research on conditions of work. Table 1 presents a listing by the ILO of the many factors likely to affect labor productivity.

This paper is an attempt to put the diverse research on these issues into some sort of perspective, both to assess the state of knowledge and to discuss future research priorities and strategies. To have reviewed in detail the various streams of research from several disciplines bearing on the issue, however, would have been a most arduous and difficult task and would have led to a treatise. The work has been narrowed in several ways. In the first place, where there exists a widely accessible, recent survey of an issue no attempt has been made to repeat its contents. Of particular value are papers by Kravis (1976), Mather (1970), and deCharms and Muir (1978). Second, our concern is primarily with work relevant to policies to raise labor productivity in developing countries. Somewhat less attention has therefore been paid to some of the comparisons of particular industries in different OECD countries, or of time-series analysis within one developed country, than these might otherwise deserve. Some of this research is of great interest, however, either in shedding light on the nature and causes of labor productivity differences between rich and poor countries, or in illustrating possible approaches to research on productivity. Third, we are concerned with empirical studies rather than with theory. For this reason, we have given little coverage to organization and \( x \)-efficiency' theories or to theories of individual motivation.

Fourth, the paper concentrates on productivity as measured by physical output or value of output per worker, not earnings. There is a wide literature on the determinants of earnings differences, and under neoclassical
**Table 1**

ILO Categorization of Factors Affecting Labor Productivity

**General Factors**

- Climate.
- Geographical distribution of raw materials.
- Fiscal and credit policies.
- General organisation of the labour market.
- Proportion of the labour force to the total population, degree of unemployment, of labour shortage and of labour turnover.
- Technical centres and information concerning new techniques.
- Commercial organisation and size of market.
- General scientific and technical research.
- Variations in the composition of the output.
- Influence of low-efficiency plants and their varying proportion in total output.

**Organisation and Technical Factors**

- Degree of integration.
- Percentage of capacity used.
- Size and stability of production.
- Quality of raw materials.
- Adequate and even flow of materials.
- Subdivision of operations.
- Balancing of equipment.
- Multiple machine systems.
- Control devices.
- Quality of output.
- Rationalisation and standardisation of work and material.
- Layout and location of the plant.
- Maintenance and engineering services: safety, light, sound, ventilation, air conditioning, telephone, etc.
- Availability, fitness and accessibility of tools.
- Wear and tear of machines and tools.
- Amount of machinery (or power) available per worker.
- Proportion of maintenance labour to operating labour.
- Length and distribution of working hours.
- Selection of personnel.

**Human Factors**

- Labour-management relations.
- Social and psychological conditions of work.
- Wage incentives.
- Adaptability to, and liking for, the job.
- Physical fatigue.
- Composition (age, sex, skill and training) of the labour force.
- Organisation of the spirit of emulation in production.
- Trade union practices.

theory with certain assumptions, earnings differences can be used to measure productivity differences. However, market imperfections in LDC's make earnings a very imperfect proxy for productivity. The paper is also restricted to productivity differences per hour worked. Productivity differences per worker will depend also on number of hours worked in a given period, which may depend on the institutional length of working day and number of days vacation, on absenteeism, sickness, and time lost due to industrial accidents, etc. Although these may depend on some of the same factors affecting productivity per hour, to explore them fully would have taken us too far afield.

Fifth, we do not survey the large literature on effects of research and development and innovation on productivity.

After a brief discussion of measurement and other conceptual problems, we follow the structure suggested in Table 2. We start with a brief survey of the literature on general comparisons of productivity on the lefthand side of the table, and move rightwards onto studies attempting to attribute differences to causes. First are the labor quality variables of obvious policy interest: education, nutrition, health and living conditions and other worker characteristics. Then we discuss worker motivation and links between financial incentives and productivity. Finally there is a discussion of the effects of the organization of work and other elements of management.

Research into each of these influences on productivity has drawn on several different types of evidence. First are differences by level of aggregation: nations and regions, industries, firms, and single individuals. Then there are different methods of research - some studies have looked at changes over time, some at cross-section comparisons at one point of time and others have controlled experimental evidence. Using the classification listed down the side of Table 2 lets us highlight some common methodological problems, which we discuss in the concluding section.

Problems of Concept and Measurement

There are a number of conceptual issues in determining what to look at. Various readings in Dunlop and Diatchenko (1964) discuss alternative measures of labor productivity used in Eastern Europe, e.g. productivity for socially necessary output, productivity of direct and indirect labor (using input-output matrixes for labor coefficients) and productivity of embodied labor (reducing capital to past or 'dead' labor).

Comparing the productivity of single factors may be of very limited use if the technologies used are very different. Different capital intensities may explain a large part of differences between countries, and obscure other differences. One should either make comparisons of labor productivity with the same technique, or else compare total factor productivity. Total factor productivity may be as interesting for comparing management effects, since managers who use labor inefficiently may also use other factors inefficiently.
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Table 2: TYPES OF PRODUCTIVITY COMPARISONS MADE, BY AUTHOR AND DATE.
Measurement problems are discussed extensively in Kravis (1976), UNECE (1972), ILO (1949), Dunlop and Diatchenko (1964), Creamer (1972), Daly (1972) and Nadiri (1970) and will be introduced only briefly here. Measuring labor productivity requires measurement of both output and labor input. Output is most easily measured by counting physical units produced of a narrowly defined good. However comparing goods produced by different people, factories or countries may not be easy, owing to quality differences. This might especially be a problem when comparing productivity of service industries, since the quality of many services is likely to be a function of the labor devoted to them — in other words, quality might be inversely related to productivity, if this were measured in terms of the number of services supplied.

Although, as we discuss below, there are many productivity studies that do focus on a single product or work activity, the general conclusions that can be drawn from these are extremely limited. Normally we want to be able to compare situations where the goods and services produced are not homogeneous. Any aggregation of different products requires some measurement of relative value. Where this involves a comparison of firms, operating in different product or factor markets, or at different points of time, this introduces familiar index number problems. Which price should be used to value output? Which output proportions should be used for comparisons when aggregating productivity indexes for single goods into an overall productivity index?

Comparisons of the value of net output would be the conceptually preferred method but are difficult to make. Net output requires information, not only on the value of purchased inputs but also on the flow of capital services. Value-added is a simpler alternative, but still requires a large amount of information. Gross output is therefore sometimes used as a proxy, but is of course affected by different degrees of product integration.

There are problems of measuring inputs also where they are heterogeneous, and appropriate weights are necessary to aggregate labor input by education level, age, sex, part or full-time status etc. There is also the question of whether to measure productivity per employee, per production worker, per week, per hour paid, or per hour actually worked.

Ideally one would find productivity indexes for single goods and form aggregates for industries or sectors using weights. In practice, unless special productivity studies are done — as by the US Bureau of Labor Statistics — one must take some aggregate output figures and labor input figures and divide them to obtain a productivity index. Unfortunately output and input indexes will usually have been aggregated separately with different weights.

Estimates of total factor productivity also require the aggregation of inputs and outputs, with similar problems. One approach is to estimate a production function and find distance of firms or countries from the regression line. One can then form an index relating actual productivity to estimated productivity with the same inputs. Nadiri (1970) discusses conceptual issues.
These include: choice of form of the production function, econometric issues of aggregation of inputs, outputs, and underlying micro production functions, issues of simultaneity which lead to biased estimates and problems of omitted inputs. See Nadiri (1970) for an extensive bibliography on these issues.

Another conceptual problem is that no firm can be more than 100% efficient. The average regression line fitted therefore represents an average amount of inefficiency. This would cause problems when comparing firms using different input patterns if pattern of inputs were correlated with average inefficiencies in use. For example, it has been suggested that it is more difficult to manage labor efficiently than other inputs (Hirschman, 1958). An alternative method developed by Farrell (1957) is to use boundary observations to define the frontier, and on the assumption that these are efficient firms, to compare other firms to the boundary ones.

This estimation of the frontier can be done using linear programming techniques. The method allows one to separate technical inefficiency from allocative inefficiency. Technical inefficiency is measured by the relative distance of the firm from the efficiency frontier, as measured along a ray of current input proportions (OA/OC in Figure 1). Allocative efficiency is measured by relative costs, comparing the costs of the firm on the frontier (at A) with the same input proportions as the original firm, with the hypothetical frontier firm with "correct" factor proportions at prevailing prices (at B).

This method has been used for cross-sectional firm studies by (amongst others) Timmer (1971), White (1976), Meller (1977), Shapiro and Mueller (1977), Pack (1974), and Page (1979). Measures of allocative and technical inefficiency can be correlated with such things as firm size, or entrepreneurs' education, labor force characteristics etc. to test hypotheses about the sources of inefficiency.

This technique has practical limitations. It is possible to carry out the analysis separately for groups of firms of different sizes, but within any size grouping it assumes constant returns to scale. A firm may appear to be technically inefficient when, in reality, the measure of capital stock has not been properly adjusted to reflect differences in the vintage of capital, or a relatively disadvantaged position with respect to a particular input, or relatively restricted access to alternative technology. Apparent differences in allocative efficiency may reflect differences in factor prices paid by the firm.

There are also statistical problems. The method relies on two to six frontier observations, and is therefore subject to errors in measurement of these extreme observations. One method of avoiding this is used by Timmer (1971). He estimates the frontier using all observations, then throws out a chosen percentage of the most efficient, to allow for measurement error, hoping the frontier will "settle down." This is rather ad hoc and has unknown statistical properties. Aigner, Lovell and Schmidt (1977) have developed a statistical approach which allows one to distinguish two kinds of disturbances,
Figure 1: Inputs used to produce one unit of output, by different firms.
i.e. the usual, normally distributed, measurement error and the one-sided inefficiency disturbance (since firms cannot be more efficient than the frontier). This gives a frontier with known statistical properties. The technique has not yet been widely used, perhaps because of its complexity. The advantage of Farrell’s technique over conventional methods is that it does not specify a priori a functional form for the frontier. However, unless one can separately estimate frontiers by firm size class, one has to assume constant returns to scale for output. Despite the above problems, and its high data requirements, the method is a promising way of analysing interfirm variation in allocative and technical efficiency.

Cross-Country Studies

There are several cross-country studies which go little beyond description, such as those by Rostas (1948), (US-UK); Heath (1959), (US-Canada); Paige and Bombach (1959), (US-UK); UNECE (1972), (Austria-Czechoslovakia-France-Hungary), Netherlands Central Bureau of Statistics (1966), (UK-Netherlands). Kravis (1976) has surveyed these studies very well. A more recent example of such a study is Bergson (1978), which compares US and USSR labor and total factor productivity, in order to find some estimate of the effect of different economic systems. Labor productivity in the USSR in 1960 was 26% or 41% of that in the US depending on whether one uses USSR or US prices as weights. Total factor productivity, taking account of labor quality and other inputs, was 37% and 52%, again depending on choice of price weights. Bergson argues that natural resource endowments are similar although those in the USSR are less conveniently located, and that economies of scale are not important. Thus, productivity differences are attributed to economic efficiency, which is in turn rather sweepingly attributed to the economic system (capitalism or socialism), modified, however, by historical and cultural factors peculiar to the countries. Bergson supports the argument by comparing factor productivity in the USSR and Europe. Socialism apparently does not lead to faster labor productivity growth when comparing the performance of COMECON and OECD countries since 1950.

The aggregate level of cross-country surveys precludes them from examining causes of differences, beyond suggesting that capital intensity differs and unquantifiable management differences may exist. Bergson’s study for example attributes differences to the economic system. The many possible alternative explanations were not examined. International comparisons for single industries or firms were therefore, a necessary extension, in order to derive policy implications. International agencies, such as the OECD European Productivity Agency and the Anglo-American Productivity Council, undertook surveys in the 1950s and 60s, as did national productivity agencies such as British Productivity Council, and similar councils in Japan and New Zealand. Several productivity journals also report on surveys and sometimes attempt explanations of comparative productivity. Examples of such journals are OECD Productivity Measurement Review, Productivity (Pergamon Press), Productivity (New Delhi), Productivity (Asian Productivity Organization), Productivity Digest (Tokyo), Productivity and Technology (New Zealand). These journals often included recommendations for methods of improving productivity, or reports on the success of some schemes.
A particularly interesting example of single-industry studies is that of the British passenger car industry (Central Policy Review Staff (CPRS), 1975), which made detailed comparisons between productivity in British and European car plants. For some cars an identical model was produced in Britain and another country. For others comparable models were taken. Care was taken to find situations with comparable capital equipment and plant layout. The conclusions are striking. It took almost twice the number of man-hours to assemble similar cars using similar equipment in Britain as in the European countries. Fifty to sixty percent more labor was required for powertrain production.

The study suggested several reasons. One was over-manning - more men per comparable production line. Task demarcation led to over-manning in maintenance. Work pace was also slower - examples of almost identical situations were found where British workers produced well under half that of continental workers. Labor disputes disrupted material supplies more strongly in Britain; quality faults led to twice as much rectification time as continental plants; and despite the fact that British manufacturers employed 50-70% more maintenance men than continental competitors, mechanical breakdowns on identical equipment led to the loss of twice as many production hours. Under-investment in capital equipment, though also contributing to lower productivity was a comparatively minor cause of lower British productivity.

Jones and Prais (1978) did a similar study slightly later and found that British car productivity was worse relative to Europe than British manufacturing productivity in general. They suggested shorter strike-free periods and smaller average plant size as contributory factors.

A study by Jorgenson and Nishimizu (1979) looks at differences in levels of total factor productivity, by industry, between Japan and the US. They find that Japanese productivity has improved relative to the US in most industries. There are also large inter-industry differences. For instance Japanese productivity in electricity, gas and water is 16% of the US, 45% in mining, 122% in light industry such as leather and 184% in financial services. It might be interesting to correlate such inter-industry differences with possible causes.

A small number of studies have approached productivity questions by enquiring about relative labor productivity in subsidiaries of multinationals. This might seem a way to get round problems of different technologies, since subsidiaries are more likely to use similar technologies than firms taken at random from the same industry in different countries. However, this is only true to a limited extent; there is evidence that multinational subsidiaries adapt their technology to factor availability; see Strassman (1968) and Pack (1974). One might also have expected that cost considerations would cause multinationals to measure and try to explain international labor productivity differences. In fact, few, if any, do, since labor tends to be a small component of costs, out-weighed especially by raw material considerations in location decisions; see Gates and Linden on this (1958, 1961).
In consequence, enquiries made of multinationals have been limited in their explanatory power. The CPRS study of the British car industry (1975) was able to make exact comparisons for models made by two subsidiaries in different countries. But such opportunities are rare. Pratten (1976b) found that the comparisons made by firms were complicated by differences in product mix and different input and output prices in different locations. Firms made their own comparisons using a variety of concepts, many only approximate. However, rather than let the best be the enemy of the good, Pratten utilized the firms’ own methods of comparison, which led him to estimate that, unweighted by firm size, labor productivity in the UK in about 1972 was 50% below that in the US, 27% below that in Germany and 15% below that in France. Weighted by the number of UK employees the differentials were all larger. About two-thirds of the unweighted difference in productivity between the UK and both the US and France, and half the difference between the UK and Germany, were attributable to economic causes such as length of production run and equipment differences, and the remainder to behavioral causes — strikes, restrictive practices, manning and efficiency. Though Pratten found that UK productivity was 11% higher than Spanish and 15% than Brazilian, the number of firms in those particular comparisons were small and no comparable analysis of the causes of differences between UK and LDCs was made. Also using multinationals, Kreinin (1965) found that LDC median labor input was 176% of US, with a large spread. Gates and Linden (1958, 1961) and Basche (1975) found LDC labor productivity to be lower than US, with large variations by region. None of these studies examine causes of variations.

Time Series Studies

Many studies measure changes in productivity over time; for instance, the US Bureau of Labor Statistics publishes studies for different industries. Kendrick and Grossman (1980), following earlier studies by Kendrick (1973) and Terleckyj (1974), analyse relative rates of growth in total factor productivity among twenty US manufacturing industries (at the two-digit SIC level). As might be expected, a positive relationship was found between spending on research and development and productivity changes, while variability in the use of capital facilities had a negative effect. The level of unionization was also negatively related to the growth of productivity but, surprisingly, both the rate of growth of unionization and the proportion of female employees were positively related to it. The Kendrick studies do not adjust factor inputs for quality change. Changes in the quality of labor or capital are therefore potential explanatory variables of relative changes in productivity, but unfortunately there was insufficient data to be able to assess the possible impact of changes in average educational levels. In contrast, Gollop and Jorgenson (1980), in describing productivity change in US industry from 1947 to 1973, make elaborate adjustments to input indices to reflect quality changes, but do not seek explanations of variation in relative "quality adjusted" productivity changes over time or among industries.
Relatively few studies look at sources of productivity change in a single industry over time. Saxonhouse (1977) does this for Japanese cotton spinning for the period 1891-1935. Unlike usual growth accounting methods, he fits a production function including "nonconventional variables", such as worker experience and primary school education, shift length and age of machinery, technical training of managers and firm age (a proxy for manager experience). These variables shift the production function in biased and nonhomogeneous ways, and affect labor absorption as well as productivity. He uses a CES function where nonconventional inputs augment labor and capital inputs equally, and also affect the substitution parameter. The main productivity gains seem to be via worker quality - education, experience, and their health and morale, via shorter shift length.

Hollander (1965) looked at sources of productivity change over time within individual plants in the U.S. rayon industry. He found that 'minor' technical changes accounted for over 79% of productivity increases due to technical change, in 4 out of 5 plants studied. 90% of technical change needed to be embodied in investment, and 80% of the investment could be replacement rather than net investment. This confirms Salter's (1960) theoretical analysis of productivity and technical change.

Sources of Productivity Differences: Labor Quality

The most obvious places to look for an explanation of labor productivity differentials are in indicators of education, health and nutrition status, and such characteristics as age and experience. It is frequently easy to measure these variables or to find acceptable proxies. There therefore exists an extensive, though patchy, body of research, both at a cross-country level, and using data collected from enterprises and individuals. In this section we look first at cross-country studies, then at micro-level research on each of the quality variables separately, and finally at work that considers the interaction of these.

Cross-Country Studies

Most such studies do not look at labor productivity as such but instead relate some measure of economic performance, such as level or growth of GNP or sectoral output, to one or more indicators of labor quality. Some go little further than correlating output with a particular quality input; others estimate a production function to allow for the effects of several inputs. For example, Galenson and Pyatt (1964) related levels of GNP, in a large sample of developing countries, to various labor quality inputs. They found that health measures (infant mortality, population/physician ratio and hospital bed/population ratio) were more effective at explaining GNP variance across LDCs than either education, nutrition or social security expenditure inputs. However calorie intake had the highest elasticity (2.27) with respect to output. Correa's (1970) cross-country correlations of the effects of health and nutrition found that only nutrition was significant in explaining differential income growth rates of Latin American countries.
Wheeler (1980) built a structural model, in which education, life expectancy and calorie consumption affected GNP either directly, or via success in manufactured exports. Structural equations related labor quality variables to appropriate inputs. Education depended on the existing capacity of the education system and on income. Life expectancy depended on the capacity of the health system and other variables. This model was estimated by three stage least squares, and thus took account of the simultaneity problems which exist in most cross-country studies. The simultaneity problem is that not only does higher labor quality affect productivity and therefore national income, but also that higher national income leads to increased social expenditures. Because the model is simultaneous, it is hard to trace the effects on production of particular policies which improve labor quality. However, the use of structural equations, and the addition of equations to make growth of population and of capital stock endogenous, allow simulation exercises which show that insufficient emphasis on education would in the long run prevent the attainment of self-sustaining growth.

Fiedler et al. (1979) provide a theoretical model which could underlie structural models of the type such as Wheeler's. They discuss input synergisms, which would affect optimal timing of investment in labor quality in developing countries.

Studies of variations in performance of large aggregates, such as countries, allow one to consider the effects of education or health improvements not simply on the productivity of the worker alone but on the productivity of other resources as well. Welch (1970) developed a framework in which education could increase productivity of labor directly (a "worker" effect), or by aiding choice of correct input proportions, or by aiding choice of optimum output mix. The latter two are allocational effects. Thus, depending on whether production functions are estimated at single crop, farm, or state level, one will capture different effects of education. This issue is dealt with later, in the section on problems and priorities for research.

Chaudhri (1974) used a similar classification when examining the effects of education on agricultural yields, and explaining smaller measured impact at farm than at state level. Malenbaum (1970) developed similar categories when studying intercountry differences in GNP level related to health. The augmentation effect for health was on days worked and vigor in a given task. The allocative effect similar to Welch's first allocational effect might include public health measures opening up previously disease-infested land for cultivation. The externality effect similar to Welch's second allocational effect might include the effects of improved health on the response to technical change, which Schultz argues is an important vehicle for education's effect (1964). Thus, the size of impact of labor quality on productivity will depend partly on the level of aggregation of data used.

Cross-country studies may suggest relationships between quality and productivity but not give much idea of how the productivity change comes about. For example, Malenbaum (1970) used infant mortality as a measure of health status explaining productivity. This does not give much guide to
<table>
<thead>
<tr>
<th>Author</th>
<th>Dependent variable(s)</th>
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<th>Research Method</th>
<th>Main Result</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aryee (1976)</td>
<td>gross firm output</td>
<td>entrepreneurial secondary education, apprenticeship and institutional training; capital</td>
<td>cross-firm regressions of owner-managed firms, Ghana</td>
<td>all three kinds of training increased output and earnings</td>
<td>used gross output and earnings, not net</td>
</tr>
<tr>
<td>Buxton (1977)</td>
<td>industry output</td>
<td>number of qualified scientists and engineers; other labor; capital</td>
<td>cross-industry production function regressions for 11 UK industries in 5 different years</td>
<td>positive effect of scientists and engineers on productivity, increasing over time</td>
<td>treats all other labor, skilled and unskilled, as homogenous. Hence separating out scientists and engineers does not indicate marginal effect of their training</td>
</tr>
<tr>
<td>Deraniyagala et al (1978)</td>
<td>supervisor’s evaluation of performance educational qualifications; individual skills</td>
<td>cross-section study of Sri Lankan clerical workers</td>
<td>coefficients of education on performance insignificant or wrong signed</td>
<td>subjective measures of performance: possibly promotion caused sample selection bias</td>
<td></td>
</tr>
<tr>
<td>Fuller (1971-1976)</td>
<td>time taken for standard task</td>
<td>3 levels of formal education; institutional, in firm, and on the job vocational training</td>
<td>cross-worker regressions for 474 turners, millers and grinders in a factory, South India</td>
<td>on-the-job and in-firm training more productive than institutional. Formal education enhanced vocational training. Selection explained 23% of performance variance</td>
<td>possible sample truncation bias by promotion. Mainly older workers.</td>
</tr>
<tr>
<td>Horowitz et al (1979)</td>
<td>downtime (inverse of productivity)</td>
<td>experience, job entry scores, specialized qualifications, grade level, marriage, log of ship size, time between ship overhaul</td>
<td>cross-shipt subsystem regressions for US ships</td>
<td>productivity positively related to experience, high school education, training, grade and entry scores</td>
<td></td>
</tr>
<tr>
<td>Layard et al (1971)</td>
<td>factory output</td>
<td>five levels of labor skill; capital</td>
<td>cross-firm production function regressions for 60 UK electrical engineering firms</td>
<td>coefficients on skilled labor insignificant or wrong-signed</td>
<td>possibly stagnant technology limited education's effect. Or product cycle effect existed</td>
</tr>
<tr>
<td>Medoff et al (1979)</td>
<td>individual’s performance ratings</td>
<td>experience; education; grade</td>
<td>cross-worker regressions for 8218 white collar workers in one US corporation</td>
<td>performance not related to experience, although earnings were</td>
<td>sample truncation bias due to promotion out of grade</td>
</tr>
<tr>
<td>Spandau (1976)</td>
<td>time taken for standard task</td>
<td>cumulated worker output</td>
<td>cross-worker learning curve for 28 South African electrical goods assembly workers</td>
<td>doubling experience decreased output unit cost by 15%</td>
<td>small sample size, possible observer effects</td>
</tr>
</tbody>
</table>
policymakers. An improvement in infant mortality might have come about as a consequence of income improvements, or any of several health interventions. These different health improvements might in turn affect productivity differently. It would be better to use some input measure of health care, such as number of vaccinations or population per physician and relate this directly to productivity.

Education

Education in all its forms, from primary schools to on-the-job training, is an obviously central determinant of productivity. Here we shall give it relatively much less attention than it deserves, because of other recent surveys. For example, there are many studies reviewing the relationship of education to individual earnings, and these have been recently surveyed (see Berry (1980), Bowman (1980), Fields (1980), and Psacharopolous (1980)). Bowman’s paper also includes a survey of cross-national comparisons and "growth accounting" studies, such as the work by Denison (1967). Only earnings studies can reflect the fact that education affects the choice of occupation, as well as productivity within an occupation. On the other hand, since the question of whether education does more than simply ration access to jobs which carry conventionally high wage differentials remains controversial, examining productivity within an occupation may shed some light on the way in which education affects earnings.

In macro-level studies, education is usually significantly positively related to productivity. In micro-studies it is usually related to earnings. However, at a micro-economic level the evidence relating education to individual productivity is fairly thin. It is strongest for agriculture. Welch (1970) found an impact of college education on US farm productivity using cross state data. He argues that education’s effects are more likely to come in allocational and externality gains than direct productivity gains, and thus state level studies are more likely to find an educational effect than farm level only. He found that college education was complementary to the rate of technical change as measured by research activity, and rate of flow of new inputs. Either extension staff days or flow of information about new inputs could be a substitute for college education. High school education had a lesser return and return did not depend on new technology. Thus education did increase productivity, and one major vehicle was in aiding adoption of new technology, similar to Schultz's (1964) hypotheses. However there were potential substitutes – e.g. more extension staff would compensate for farmers without college education.

For developing countries, the evidence linking education to agricultural productivity is surveyed by Lockheed, Jamison and Lau (1980). They find 37 data sets relating education to technical efficiency in production of either cereal crops or mixed crops. Eighty-three percent of the studies showed a positive gain in production for four years of education, 89% when weighting studies by sample size. They found that the impact of education was greater in a modernizing environment. Sixteen studies surveyed the impact of nonformal education. Eight found a positive significant effect, one negative,
the rest were insignificant. Farm productivity could rise by 7.4% due to four years of elementary education; 1.3% in traditional environments, compared with 9.5% under modern or modernizing conditions.

Aryee (1976) surveys the effect of the education of entrepreneurs of industrial firms in Ghana. Gross output and firm earnings, allowing for differences in capital inputs, were found to be correlated with entrepreneur's education at secondary level (which conveys functional literacy), with entrepreneur's institutional training (in contrast to Fuller, 1972, 1976, see below) and with entrepreneur's apprenticeship in the modern and informal sectors. These results point out that it may be important to include different kinds of education which transfer different skills.

Fuller's (1972, 1976) work for millers and grinders in two Indian factories, correlated efficiency ratings (time taken for a standard task) with three levels of formal and three kinds of vocational training. Institutional vocational training appeared to have less relation with productivity than in-firm or on-the-job training, and formal education seemed to increase the worker's ability to gain from on-the-job training. However, promotion depended more on institutional training, which implied that it was not the most productive people who were promoted.

In another cross-firm study Layard et al (1971) ran production functions for 60 electrical engineering firms, on manpower inputs of different skills and capital. The coefficients on higher levels of skill were frequently negative or insignificant, i.e. education did not seem to increase productivity. Leonor (1976) attributed this possibly to stagnant technology. An alternative explanation might be related to the product cycle, that new products need higher skilled labor, and also productivity is lower, and therefore a spurious negative relation between productivity and education of labor is obtained.

Buxton (1977) did however find that qualified scientists and engineers could increase marginal productivity, and their effect had become more significant throughout the 1960's and 70's. Buxton attributed this to a threshold effect. These results were obtained from a production function study for 11 industries in five different years, in the UK.

Deraniyagala et al. (1978) used supervisor's evaluation of performance as a productivity measure for managerial and clerical groups in Sri Lanka, and found the correlation between performance and educational qualifications across individuals to be insignificant and often wrong-signed, as was the correlation between individual skills affecting job performance, and education. Their evidence on promotion and selection would also cast doubt on human capital theorising. The most educated people were promoted, but these were not necessarily the most productive.

Experience is another method of increasing human capital, like education, and on-the-job training is frequently regarded as more efficient than more formal vocational training. The history of the Horndal factory in which productivity rose at 2% per year for 15 years with no new investment
Table 4. SUMMARY OF SELECTED STUDIES OF THE EFFECTS OF NUTRITION ON PRODUCTIVITY

<table>
<thead>
<tr>
<th>Author</th>
<th>Dependent variable(s)</th>
<th>Independent variable(s)</th>
<th>Research Method</th>
<th>Main Result</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belevady (1966)</td>
<td>paddy yield;</td>
<td>calorie intake</td>
<td>intervention study, 20 Indian agricultural workers. Half received 2400 calories, half 3000 a day, for 3 months.</td>
<td>no effect on crop yield or work output per hour on agricultural tasks</td>
<td>small sample; short period</td>
</tr>
<tr>
<td>Chamber (1979a)</td>
<td>productivity per hour.</td>
<td>arm circumference; hæmoglobin; weight for height; parasite infection; age; sex.</td>
<td>cross worker regressions, 150 Kenyan road construction workers, 1 month.</td>
<td>a one standard deviation increase in arm circumference or hæmoglobin; increased productivity by 42. Age, parasite infection, weight not significant.</td>
<td></td>
</tr>
<tr>
<td>LBD (1973)</td>
<td>physiological performance</td>
<td>arm circumference; hæmoglobin; weight; dietary intake; parasite infection</td>
<td>correlation matrices, 571 male Indonesian construction workers</td>
<td>significant correlations (102 levels) between performance and each of: arm circumference, hæmocrit, weight and vitamin C intake.</td>
<td></td>
</tr>
<tr>
<td>LBD (1974)</td>
<td>daily work output; work output in one-hour &quot;race&quot; with financial incentives</td>
<td>hæmoglobin level</td>
<td>intervention study, 249 Indonesian rubber tappers and weavers. Half received iron supplement, half placebo, for 60 days</td>
<td>anemia caused 15% productivity decrement in weavers, 25% for tappers. Iron supplementation removed differential, but did not alter productivity of non-anemic workers.</td>
<td></td>
</tr>
<tr>
<td>LBD (1975)</td>
<td>work output (moving sand)</td>
<td>hematocrit; height, weight; arm circumference; haemoglobin; dietary intake; biological analysis of nutrients; parameters</td>
<td>cross worker regressions, 198 north Indian road construction workers, over 6 weeks</td>
<td>output correlated with hematocrit (in one of two populations), height, weight, arm circumference, protein status, vitamin A status. No effect of current calorie intake</td>
<td></td>
</tr>
<tr>
<td>LBD (1977)</td>
<td>time taken for each moving task</td>
<td>haemoglobin</td>
<td>intervention study, 181 Kenyan road construction workers over 3-6 weeks. 67 received 700 calorie supplement, 62 matched controls. 24 received iron supplement, 20 controls.</td>
<td>iron supplementation raised productivity, especially for workers with heavy parasite loads. Low weight for height associated with productivity in cross-section, but calorie supplementation had no productivity effect</td>
<td>short-time period. Use of &quot;finish-and-go&quot; system may have involved different motivation from day work.</td>
</tr>
<tr>
<td>Laminck et al (1978)</td>
<td>daily cane output, daily work time; % of maximal capacity in work</td>
<td>energy intake, age</td>
<td>intervention study of Guatemalan cane cutters over 18 months. 19 received 550 calorie supplement (average per day), 23 controls.</td>
<td>increased energy intake led to increased % of maximal capacity sustained to work. However productivity and work time did not increase.</td>
<td>small sample. Possible observer effects (controls increased productivity in 2 of the 3 intervention periods.)</td>
</tr>
<tr>
<td>Laminck et al (1978b)</td>
<td>daily cane output</td>
<td>height, age, weight; upper arm muscle area</td>
<td>cross worker comparisons, 138 Guatemalan cane cutters</td>
<td>daily productivity decreases with age, especially if current calorie intake is low. Height associated with higher productivity, weight and muscularity are not.</td>
<td></td>
</tr>
<tr>
<td>Keys et al (1950)</td>
<td>performance, various tasks</td>
<td>calorie intake</td>
<td>intervention study, 32 US volunteers on 24 week starvation diet.</td>
<td>After 24 weeks, muscle strength fell 30%, precision of movement 13-202.</td>
<td>starvation results likely to differ from effects of permanently lower diet, due to psychological adaptation.</td>
</tr>
<tr>
<td>Keys et al (1948)</td>
<td>output per hour, shifting debris</td>
<td>calorie intake</td>
<td>intervention study, 20 German railway workers over 18 months</td>
<td>Increase in calories from 2400 per day to 3000, could increase productivity by 47%. Incentive of cigarettes could raise productivity a further 55%. No controls.</td>
<td></td>
</tr>
<tr>
<td>Kesten et al (1946)</td>
<td>output per hour</td>
<td>calorie intake</td>
<td>intervention study, 31 German mine workers, over 6 weeks.</td>
<td>Increase from 2800 to 3200 calories daily, raised productivity by 37%, to 3600 by 63%.</td>
<td>short period, possible observer effects, no controls</td>
</tr>
<tr>
<td>Author</td>
<td>Dependent variable(s)</td>
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<td>Research Method</td>
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<tr>
<td>same</td>
<td>output per hour of steel hammer</td>
<td>calorie intake</td>
<td>intervention study, German steelworkers</td>
<td>Increase of 400 calories increased productivity 22%</td>
<td>Other possible correlated factors not included</td>
</tr>
<tr>
<td>Popkin (1978)</td>
<td>output per day; active time per day; absenteeism; over 6 weeks</td>
<td>hemoglobin; height; weight; socioeconomic variables</td>
<td>cross-worker regressions, 20 Philippine road construction workers, over 2 days</td>
<td>Anemia associated with lower productivity, more absenteeism, less active work time per day</td>
<td>Very few observations, spread over 3 tasks</td>
</tr>
<tr>
<td>Satyanarayana et al (1972)</td>
<td>absenteeism; output per day</td>
<td>calorie intake</td>
<td>intervention study, Indian coal miners over 6 months. 76 received a 500 calorie supplement, 85 controls. Preintervention intake had been 3100 calories</td>
<td>Supplement did not affect productivity or absenteeism</td>
<td>Shortage of tube to fill prevented any potential productivity increase being observed. Disincentives to attendance (4 hour daily travel time)</td>
</tr>
<tr>
<td>Satyanarayana et al (1977)</td>
<td>daily work/ output over 3 months</td>
<td>height; weight; height for height; lean body weight; socioeconomic variables</td>
<td>cross section comparisons, 59 male Indian factory workers, making detonator fuses</td>
<td>Work output correlated with weight and lean body weight. Not correlated to height or weight for height once weight was included, nor to length of service or socioeconomic variables. Weight increase from 45 kg, to 55 kg raised productivity 13%, to over 60 kg 27%</td>
<td></td>
</tr>
<tr>
<td>Satyanarayana et al (1978)</td>
<td>daily work output over 3 months</td>
<td>weight; height</td>
<td>cross section comparisons, 70 female Indian factory workers, making fuses.</td>
<td>Increased weight correlated with increased output until obesity led to eventual decrease</td>
<td>VO2 max and fat related to physical fitness as well as to nutrition status.</td>
</tr>
<tr>
<td>Spurr et al (1977)</td>
<td>daily cane output over 3 months</td>
<td>maximal capacity (VO2 max); body fat; height, weight; lean body weight; age</td>
<td>cross section regressions, 46 Colombian sugarcane workers</td>
<td>Productivity positively related to VO2 max, negatively to fat. Weight, height and lean body weight positively related to VO2 max. No age effect on productivity.</td>
<td></td>
</tr>
<tr>
<td>Viteri (1975)</td>
<td>weight of cane cut daily</td>
<td>calorie intake</td>
<td>intervention study of Guatemalan sugarcane workers. 96 workers received 650 calorie supplement, 64 controls.</td>
<td>Cane output rose 0.2 tons per day, 0.1 tons for controls. Supplemented group maintained body weight better, performed a standard task faster, and negative age effects on productivity diminished</td>
<td>Well controlled study</td>
</tr>
</tbody>
</table>
was often been cited. (Arrow (1962) cites Lundberg (1961)). Whether this reflects growing management or growing worker experience, or both, is not clear. Theoretical discussions of this issue include a well-known paper by Arrow on learning by doing (1962). On the other hand, work by Medoff and Abraham (1979) found that within four major US corporations, although greater experience was associated with greater earnings for white collar workers, it was not associated with greater productivity, as measured by performance ratings.

Spandau (1976) studied a South African electrical goods assembly firm, and fitted a learning function for 28 workers. A doubling of worker experience, as measured by cumulated output, could decrease cost by 15%. The existence of such a learning curve, coupled with faster labor turnover, in South Africa, was held to be one reason for lower productivity relative to a German firm.

A recent study relates downtime (the inverse of productivity) of various subsystems (boilers, engines, gear systems, gun systems etc.) of ships in the US Navy to the quantity and quality of the men assigned to maintain them (Horowitz and Sherman, 1980). Several occupations were studied and there were considerable differences between tasks in the relative importance of prior education, current pay grade training and experience. In general, however, the results are in the expected direction.

**Nutrition**

It might seem self-evident that better nutrition can improve productivity of malnourished labor, and the fact that private firms have often apparently thought it worthwhile to supply or subsidise meals might serve as casual evidence. However, it has been surprisingly difficult to quantify the effect at an individual level and the interaction between nutrition and education, motivation, disease is complex. For example, malnutrition in childhood can affect intelligence, school performance, subsequent earnings in adult life, and the education and nutrition of the next generation. Links between education, health and nutrition are reviewed in Cochrane et al. (1980) who survey evidence on the effects of parental education on child health and nutrition.

Theoretical models are scarce: Bliss and Stern (1978) develop the efficiency-wage model of Mirrlees and Stiglitz, whereby a productivity-wage relationship for workers near subsistence may cause employers to pay an efficiency wage, i.e., one which is independent of labor supply and demand conditions. However, the relationship is likely to be disturbed by differences in education, disease, and type of work undertaken. It is found that the model's substantive prediction of a uniform real wage over time and in cross-section, is not borne out for Indian agricultural wage data.

Simple models of an effect of nutrition on productivity are unlikely to stand empirical testing. Disease affects absorption of nutrients by the body, and nutritional status affects both the susceptibility to disease and also effort. The hourly wage rate received (which may depend on productivity, if a worker receives piece rates) also affects effort. Hence, isolating the impact of nutritional status on productivity may be difficult.
Garza and Scrimshaw (1976) found large differences in inter-individual needs in protein-calorie intake were necessary for subjects to remain in nitrogen balance. Nicol and Phillip's (1976) work on Nigerian men found that adaptation to a low protein diet could occur. The effect of nutritional deficiencies may thus vary by individual, by ethnic background and by past nutritional history. Efforts to establish minimum requirements for nutrient intakes have proved difficult. Thus the nutritional intake-productivity relation is unlikely to be very simple or stable.

Evidence from the 1940s and 50s suggested that a calorie intake-productivity relation did exist. Experiments in wartime Germany, reported by Kraut and Muller (1946), found that productivity rose when extra calories were provided, but they lacked a control group, and could not exclude training and motivation effects. The Minnesota starvation experiments reported by Keys (1950) likewise found productivity fell with starvation, but this study on Americans need not generalize across countries where people may adapt to lower calorie diets. U.S. army trials reported by Johnson et al. (1941-46) found performance and morale of soldiers deteriorated on a 7 day limited calorie intake diet, but is open to the same objections as the Minnesota study.

There is evidence from somewhat less artificial studies: Stearns (1950) found that productivity in road construction on the Pan American highway increased up to 500% when workers were housed in camps with a better health environment, and provided with all their meals. Whereas in 1943, a labor force of about 70% Costa Rican and 30% (more productive) US workers moved 240 cubic meters of earth a day per man, by 1946 the corresponding figure for a 90% Costa Rican labor force was 1005. FAO (1962) cites examples where the provision of cooked meals raised productivity 30% in Rwanda, and cut turnover from 60-66% at a Madagascar sugar refinery. It cites a canteen in South Vietnam which raised factory productivity 50%. Buzina et al. (1971) found that Yugoslavian construction workers boarding alone had poorer energy and protein consumption, and were absent 22.2 days a year, as against 2.5 days for workers living with their families.

Such studies, however, did not control for other factors which affect productivity, such as working conditions, motivation, payment systems, experience levels, and technology. More recent studies both of cross sections and of intervention, have made better use of controls. Both deficiencies of specific micro-nutrients and of calories have been studied.

(a) Specific Nutrients

The most clear cut evidence of nutritional impact is for specific nutrients where intervention studies are most feasible, usually in the form of double kind studies. Borzok (1945) found that vitamin supplements raised output of California aircraft workers by 4.1% per year, of which 2.6% was due to productivity increases, 0.9% due to a fall in absenteeism, and 0.6% due to a reduction in turnover. The impact of specific nutrients on productivity has been taken as self evident, e.g., vitamin A deficiency causes blindness hence,
loss of output in LDCs, but it seems no one has quantified this apart from work by INCAP (1979) estimating its effects on mortality. Quantification has been attempted for iron. Basta (IBRD, 1973) found a correlation in cross section between performance in physiological tests and iron intake of construction workers. Follow-up studies (IBRD 1974) found that iron supplementation could cause a 15% productivity improvement for rubber tappers and 25% for weeder. Popkin's (1978) study for Philippines road construction workers found a cross-section correlation between productivity and hemoglobin levels. Gardner (1977) found a 20% reduction in performance on physiological tests for anemic tea plantation workers, confirming Basta's work. Kenyan (IBRD, 1977) and Indian (IBRD, 1975) road construction studies also found a relation between productivity and iron levels. The evidence that iron status affects productivity in heavy manual labor thus seems convincing.

(b) Calorie Intake

Results for calorie intake are less clear. Since methods of directly weighing and measuring food intake are difficult to administer, proxies must usually be used. Such variables include weight, height, weight for height, arm circumference and lean body mass (mass adjusted for fat content—i.e. skeletal plus muscle mass). These measure different aspects of current and past nutrition and this may account somewhat for the rather mixed empirical results. Age also affects nutritional needs and makes a difference as to how bad the effects of poor nutrition are. Good nutrition is crucial for very young children and pregnant women, and Immink's work (1978) suggests it may be important in maintaining productivity of the old. Climate affects nutritional needs and colder climates raise basal metabolic energy needs.

Several studies were made for road construction, where individual worker output could be monitored fairly easily. Chesher (1979) for Kenya found productivity did not depend on current calorie intake although it depended on arm circumference, an indicator of past calorie intake. Popkin (1978) in Philippines found no effect. On productivity of height or weight. In India weight for height, and arm circumference, but not current calorie intake were found to be significant (IBRD 1975). Basta (IBRD 1973) used physiological tests in Indonesia rather than actual productivity and found no effect of greater arm circumference, weight or height, on ability to perform step tests.

For sugarcane cutters: in Jamaica, Heywood (1974) found weight for height significantly affects productivity; for Colombia a negative effect of fat content was found, (Spurr, et al. 1977a); and also a positive effect of maximal aerobic capacity (a measure of lung function) and height (Spurr et al. 1977b); for Guatemala Immink, et al. (1978b) found height had a positive effect, current intake a positive effect for older workers, but muscularity and energy store had no effect.

For agricultural workers in India, Belavady (1966) found no productivity difference at different calorie intake levels. However, Viteri (1971) in Guatemala compared peasants and army recruits with differing nutritional histories, and found that physical capacity did vary with nutrition. He was not able to measure productivity directly, as the tasks undertaken
Satyanarayana et al. (1977) found that industrial productivity (as measured by number of bundles of detonator fuse completed) depended on lean body weight and less strongly on height, and directly observed a faster pace of work after a lunch provided by the firm than before lunch. Similar studies for female workers soldering fuse wire (1978) found that higher weight (implying usually better nutrition) improved productivity, until the point where obesity began to lower productivity.

Experiments with calorie supplementation have been less successful than for micro-nutrients. There is agreement that body composition improves with calorie supplements, but the productivity effects are less consistent. For Kenyan road workers, nutritional status improved after 4 weeks of calorie supplementation, but not productivity (IBRD, 1977). For Indian coal miners a 6 month intervention had no effect on task performance (Satyanarayana et al. 1970). However this may be attributable to poor experiment design, as insufficient capital equipment (coal trucks) was available to handle increased output. No effect was found for Guatemalan sugarcane cutters after 15 months of diet supplementation (Immink, 1978a), although the author blames poor experiment design and is undertaking further work to try to detect an effect. A positive effect was found for Jamaican sugarcane cutters, (Heywood, 1974) and for Guatemalan workers at an agro-industrial sugar complex (Viteri, 1975), where work intensity increased, and the negative effects of age on productivity diminished.

In all intervention studies, observer effects may be important. Immink (1978a) fed two groups of workers a high and low (zero) calorie drink as a diet supplement, in a doubleblind experiment. The latter also increased productivity contrary to what one would expect, since diet was unchanged. Similarly the IBRD (1977) in an iron supplementation study, found that a vitamin C placebo could also raise productivity. Typically, however, these observer effects do not persist, whereas nutrition interventions can lead to sustained productivity increase. This does point to a need for monitoring productivity over a reasonable period whilst maintaining other conditions constant.

Health

As for nutrition, because it seems so self evident that disease affects labor productivity, theoretical modelling has been limited, and estimates of economic costs of disease are often made on an ad hoc basis with untested quantitative assumptions. Micro-studies (perhaps as a consequence of lack of good theory) frequently are unable to detect large effects. Most empirical work has studied absenteeism or productivity in one occupation, i.e., the direct labor augmentation effects. Effects on allocation of inputs, and indirect effects via education, nutrition and motivation are sometimes cited; possible external effects via adaptation to new technology have been less often studied.

At a macro level, Griffith et al (1971) used time series regressions for Sri Lanka, 1948-58, of per capita national income, on investment as a proportion of national income, and on health expenditure per capita. They found that the response elasticity with respect to health expenditure was greater than to physical investment (0.5 as against 0.2).
| Table 2: SUMMARY OF SELECTED STUDIES OF THE EFFECTS OF HEALTH ON PRODUCTIVITY |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Author                          | Dependent variable(s)           | Independent variable(s)         | Research Method                 | Main Result                     | Limitations                     |
| award et al. (1970)             | 3 pulmonary function measures,  | schistosomiasis infection       | cross-section comparison of     | up to 16% increase in           | result depends on small        |
|                                | oxygen intake at 3 different    | (egg count)                     | 19 severely infected           | physiologically capacity, even  | sample number (19) of          |
|                                | work levels                     |                                | Sudanese (case) cleaners, 37   | despite superior nutrition      | heavily infected individuals    |
|                                |                                 |                                | non-infected villagers and 165  | status of canal                  |                                |
|                                |                                 |                                | lightly infected villagers      | cleaners for severe            |                                |
| Baldwin et al. (1974)           | weekly earnings, days worked    | Schistosomiasis infection       | cross worker regressions for    | parasite affected male         | did not control                |
|                                | daily, weight per week;         | (schistosomiasis, ascaris,      | 60 male, 60 female, strongyloides | productivity                  | other workers that             |
|                                | difficulty of task time         | strongyloides, hookworm, age,   | workers (total sample 458)     | (health, nutrition), use of    | characteristics were           |
|                                |                                 | education, outside work,        |                                | of a single occupation         | not positively correlated, thus |
|                                |                                 | fireproof housing               |                                | implies sample selection       | multicollinearity              |
|                                |                                 |                                |                                | bias sample size               | problems                      |
|                                |                                 |                                |                                | very small for num-             |                                |
|                                |                                 |                                |                                | ber of independent variables   |                                |
|                                |                                 |                                |                                |                                |                                |
| Ceely (1975)                    | Crop yield, crop allocation,    | 3 levels of severity of         | cross section comparison of     | severe malaria                  |                                |
|                                | amount of manuring and land     | malaria infection. Controls for | 39 Tanganayek farmers over 2    | lowers yields, decreases       |                                |
|                                | clearing                        | farm specific effects, by       | years                           | allosterism to      |                                |
|                                |                                 | comparing farmers with          |                                | infant crops, decreases        |                                |
|                                |                                 | own performance in previous,    |                                | weeding and land mainte-       |                                |
|                                |                                 | nonidential material.           |                                | nance, decreases               |                                |
|                                |                                 |                                |                                | efficiency of                  |                                |
|                                |                                 |                                |                                | clearing land.                 |                                |
| Fowter et al. (1972)            | productivity over 6 months,     | schistosomiasis infection       | cross worker regressions,       | infection causes                |                                |
|                                | bonus earnings over 2 years     | (schistosomiasis, tenia,      | Tanganayek sugar case workers   | 3-5% productivity decrease     |                                |
| Giffith et al. (1971)           | per capita national income      | physical investment = 0.5,      | time series data, Sri Lanka,   | similiarity problems, omitted   |
|                                |                                 | 0.2 with health 0.5,           | 1965-68                         | variables, health              |
| Malashan (1970)                 | agricultural output             | labor force in agriculture,     | cross country regressions for   | use health output              |
|                                |                                 | % land irrigated,              | 35 poor countries              | not input series               |
|                                |                                 | malari death rate,             |                                | inappropriate                 |
|                                |                                 | literacy rate                  |                                | multicollinearity              |
|                                |                                 |                                |                                | problems                      |
|                                |                                 |                                |                                |                                |
| Name                            | same                            | same state regression,         | health accredited for 60% of    |                                |
| Rice output                     | % labor force in agriculture,   | 29 Mexican states              | explained variation             |                                |
|                                | % land irrigated,               |                                |                                |                                |
|                                | % malari death rate,            |                                |                                |                                |
|                                | literacy rate                   |                                |                                |                                |
| Agricultural output            | fertility input, double         | cross-block regressions,        | drinking water accounted for    |                                |
|                                | cropping, numbers of new       | 30 Indian development blocks,   | 11.2% of explained              |                                |
|                                | primary schools, new            | Mahalrashtra and U.P.           | variance                        |                                |
|                                | irrigations and drinking wells |                                |                                |                                |
| Nedd et al. (1978)             | change in agricultural         | change in mortality rate        | mortality change                |                                |
|                                | productivity                    |                                | elasticities 65% of total       |                                |
|                                |                                 |                                | productivity, elasticity 0.3.   |                                |
|                                |                                 |                                | higher productivity            |                                |
|                                |                                 |                                | rise in previous                |                                |
|                                |                                 |                                | "high malaria areas"            |                                |
|                                |                                 |                                | attributed to                   |                                |
|                                |                                 |                                | control program                 |                                |
| Vatsaloo et al. (1977)          | as Baldwin (1974)               | cross-state regression, 15      | mortality change                |                                |
|                                |                                 | Indian states 1950-50 to 1965-5| elasticities 65% of total       |                                |
|                                |                                 |                                | productivity, elasticity 0.3.   |                                |
|                                |                                 |                                | higher productivity            |                                |
|                                |                                 |                                | rise in previous                |                                |
|                                |                                 |                                | "high malaria areas"            |                                |
|                                |                                 |                                | attributed to                   |                                |
|                                |                                 |                                | control program                 |                                |
|                                |                                 |                                | mortality change                |                                |
|                                |                                 |                                | elasticities 65% of total       |                                |
|                                |                                 |                                | productivity, elasticity 0.3.   |                                |
|                                |                                 |                                | higher productivity            |                                |
|                                |                                 |                                | rise in previous                |                                |
|                                |                                 |                                | "high malaria areas"            |                                |
|                                |                                 |                                | attributed to                   |                                |
|                                |                                 |                                | control program                 |                                |

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Ram and Schultz (1979) correlated the change in agricultural productivity for Indian states, between 1958-9 and 1964-5, with the change in the mortality rate. They found that the mortality rate could 'explain' 28% of the productivity increase. They argued that this is confirmed by the fact that output in labor intensive crops rose more in previously high malaria areas, over the same period, when malaria was being controlled. Unfortunately, their analysis takes no account of the simultaneity problem that increased output presumably benefits health. Nor of spurious correlation - one would expect malaria incidence and agricultural productivity to be both connected to irrigation. Moreover, making economic output dependent upon a health output measure (mortality) rather than health input, is methodologically weak.

Malenbaum regressed agricultural output in 1960 for 35 poor countries on various inputs including health (labor, fertilizer, infant mortality rate, population per physician, dysentery and malaria cases per 100,000 population, and literacy). Labor and fertilizer accounted for 43% of explained variance, literacy 3%, and health the remaining 54%. However, explanatory power was low ($R^2 = 0.17$). On a smaller sample of 22 countries ($R^2 = 0.62$) health variables accounted for almost 80% of explained variance. Similar regressions were performed across states within Mexico, Thailand and India separately, in 1960. For Mexico, health variables accounted for 40% of explained variation.

In Thailand the health variable was not significant, perhaps because a poor variable was used (percentage improvement in malaria death rate). In India specific variables such as number of smallpox vaccinations, number of sanitary latrines constructed, and especially number of drinking wells constructed per year, were significant in explaining variance of agricultural productivity by state.

There is considerable casual evidence that the alleviation of specific diseases has had a substantial labor-augmenting effect. Winslow (1951) cites the Philippines where the institution of a malaria control program in 1946 led to absenteeism falling from 35% to 2-4%, and where 20-25% fewer laborers needed to be recruited. Similarly in Transvaal and Natal, malaria eradication cut recruitment requirements by 30-40%, and in Southern Rhodesia absenteeism fell from 25% to zero. Malaria eradication was seen as sufficiently profitable that in British Guyana private sugar producers instituted control (Taylor and Hall, 1967). Mach (1979) cites productivity in rice production rising 15% for Burma and Pakistan in the year following the institution of malaria control. For hookworm, a 1926 study cited by Winslow (1951) suggested eradication could raise productivity by 25%.

Prescott (1979) surveys a range of casual evidence for the effects of several parasitic diseases on mortality, disability and debility. He finds little solid evidence of the size of effect. In cost benefit studies of malaria eradication, the assumed work efficiency loss varies from 10% of yearly production, 20% over six weeks, to be equivalent of a 10 day loss of output. These estimates are not based on empirical evidence. For onchocerciasis, Prescott (1979) cites Prentice and Macrae's study of recruitment of labor on a tea plantation. Selection was on the basis of a test of weeding and clearing a fixed area under supervision. Of the 23 workers selected, none were infected with onchocerciasis, as against 20 of the 23 not selected. This is indirect
evidence of a productivity decrement. For filariasis the only evidence Prescott (1979) finds, is indirect. Muhondwa reports that 10 out of 23 men choosing hydrolectomy treatment, gave as a reason, that the condition caused so much pain as to impair efficiency. For Chaga’s disease, Prescott cites Macedo et al.’s inability to measure significant differences in physiological performance, between infected and non-infected individuals.

There is also evidence of the allocative impact of disease control. Opening up previously unusable land is one justification offered for the West African program of onchocerciasis control, and for programs against trypanosomiasis (sleeping sickness). Sorkin (1974) credits malaria control with the opening up of the Rapti Valley in Nepal. Malaria has frequently impeded infrastructure investment. Mach (1978) cites the Panama Canal where yellow fever and malaria deaths caused the suspension of work for a while, Indian railway construction which was hindered by malaria, and the construction of the Sarda Canal 1920-29 (where 96% of the laborers suffered from fever) and which had to be suspended until malaria was controlled.

Another allocative effect of the incidence of disease is its consequence for occupational choice, with unquantified effects on productivity. Certain diseases such as leprosy may totally incapacitate people, or cause them to be used for barely productive tasks, as is often the case with blindness. Some studies attempt to measure the loss due to total inhibition from productive activity, often using average earnings. Prescott (1978) points out the weaknesses of this procedure: the average population is not perfectly healthy, and marginal, not average, product should be used, especially since labor may be in surplus.

Diseases may also affect labor allocation more subtly. For example, intestinal parasites or anemia may lead to choice of an occupation not involving heavy manual labor. If labor is heterogeneous and occupations have differing skill and ability requirements, then disease may impede the most efficient allocation of individuals to jobs. Epilepsy, for example, may preclude individuals of high ability from taking jobs where there is risk of damage to machines or danger to other people in the event of a seizure. Pollen allergy might prevent a muscular individual from undertaking manual labor out-of-doors.

A very important externality may be the impact of disease on the adoption of new technology. For education this seems to be a major effect (see above) but it has surprisingly not been studied for disease. Disease may lead people to avoid risks and reduce specialization. For example in agriculture, crops with very time-specific labor input needs may be avoided, to prevent disease from debilitating the labor force at some crucial time. In industry highly integrated processes and high division of labor may be avoided, to prevent losses if disease affects a crucial sector of the labor force.

Conly’s (1975) study for malaria brings out the importance of such allocational and dynamic externality effects on productivity. She looks at the effect of three degrees of severity of malaria infection for Paraguayan farmers, for whom labor supply was a constraint on development. Although the study could not control for many factors, and experience in farming and severity of infection were correlated, the results were interesting.
Performance was compared to their own family's performance in the following year, to remove family-specific factors such as experience. But allocational effects were more important. Severely affected farms concentrated on cash and important crops and yields fell sharply for minor crops. Manioc consumption rose. This is a crop where labor substitution across years is possible, as one can neglect the crop for months with little ill effect. Maintenance and weeding were postponed to the following year. There was less land clearing and extension of holdings.

Recent micro-level studies seem to be almost exclusively of the effect of schistosomiasis on the productivity of agricultural laborers. Fenwick and Figenshau (1972) resurveyed a Tanzanian estate where Foster (1967) had previously found no effect of infection on work intensity, but some on absenteeism. The longer period of exposure and more settled labor force, may have led to a 3-5% productivity effect being observed, as measured by bonus earnings over two years and by direct productivity figures for a 6-month period. Baldwin and Weisbrod et al. (1972) were unable to find a systematic effect for 5 parasitic diseases on productivity on a St. Lucia banana plantation, using as measures weekly earnings, daily earnings, days worked per week or choice of difficulty of task. A resurvey (Weisbrod, 1977) two years later hoping to find that coefficients had become more significant reflecting a lagged disease effect, found, if anything, the opposite. Both studies were criticized because infection by parasites at one time was only a poor measure of permanent health status, due to reinfection and cure. Collins et al. (1976) were unable to find any effect on physiological capacity of Sudanese canecutters as measured by bicycle and step tests. In field studies no productivity effect was observed either. A slight tendency of the noninfected to sustain a higher percentage of their maximal lung capacity usage was offset by their lower efficiency in terms of cane cut per unit oxygen intake. This was probably because lower exposure to infection was correlated with shorter experience in canecutting.

The most positive results are those of Awad el Karim and Collins et al. (1979) where careful differentiation by severity of infection, allowed measurement of an impairment in physiological capacity of up to 18% for severely infected canal cleaners as against other villagers, despite the former having superior nutritional status.

A promising route for future research into parasites might be to measure impact on nutritional status and hence productivity, or alternatively for hookworm to measure impact on iron levels and hence productivity. Specifying some mechanism for impact of disease on productivity might enable effects to be captured.

**Living Conditions**

The effect of general living conditions in labor productivity might seem important but its collinearity with nutrition and health, and interactions with education and health, makes quantification difficult. A general measure of living conditions is difficult to conceptualise. Even a measure of housing quality needs to combine such factors as room size, convenience and amenities for families of varying sizes and social habits. U.S. housing projects often
found that superior housing, as measured by physical indicators, was associated with social disorders, because of a breaking down of community ties. One might wish to combine housing, community spirit, water supply, family relationships into an index of environmental quality in order to relate it to productivity. Conceivably, though, such an index might have different weights for different occupations. Physical environment might affect manual productivity; the availability of reading materials and quiet surroundings is likely to affect educational attainment; and the social and emotional environment may affect reaction to discipline, ability to adapt, to cope with work stresses, etc.

Burns and Grebler (1977) did find that housing had an effect on productivity. They survey 7 housing projects, 4 in LDC's, 3 in the U.S. A productivity effect was found in 2 out of 4 of the LDC's (it was not measured for the U.S.) and in 2 out of 7 cases health improved (1 in 4 for LDC's). The productivity improvement was linked to type of housing improvement. The strongest effect was in the coal industry in Hambaek, Korea; under conditions of cold winters, and a past strong unsatisfied demand for more housing, it is plausible that the halving of occupancy rate per room could aid productivity. A positive, though once-for-all, productivity effect was observed for synthetic fiber workers in Zacapa, Mexico, together with longer run improvements in health. The lack of observable productivity effect for the two steel industry cases was attributed to a fall in house size despite quality improvements, confirming theoretical arguments for need for a careful construction of an index of quality. These studies control for health and education levels although not necessarily motivation. In Hambaek it was observed that the productivity of workers not rehoused also rose (though by less), perhaps in an attempt to impress management and seem deserving of rehousing.

Other Aspects of Labor Quality

(a) Age

There is evidence that age-productivity profiles do not necessarily correspond with age-earnings ones, contrary to human capital models of earnings. Earnings within occupations tend to increase with age, whereas for nonmanual jobs some intelligence measures deteriorate with age, e.g., Correa (1963) cites studies by Cummins and Fagin, and by Gagne and Fleishner. Medoff and Abrahams (1979) cite a Harvard Business School study where older engineering technicians were given easier tasks yet had lower rated performance by supervisors than younger workers. Kutscher and Walker (1960) found little effect of age on productivity for clerical workers in the US, and that individual variation within age groups far outweighed differences between age ranges. Possibly, however, this reflects some "self-selection." There was narrower individual variation among older workers, perhaps because the worst had been dismissed or retired and the best had been promoted. It might, however, merely indicate that age leads to more consistent performance and more reliability. The effects of age on creativity, entrepreneurial conservatism, and mental sharpness remain controversial.
It seems plausible that age effects might be more detectable in manual labor. Immink (1978) found that physiological capacity decreased with age, but that older workers compensated by sustaining a higher percentage of maximum at work, and so were not less productive. Viteri (1975) found that age effects in industrial workers could be removed by better nutrition. Eriksson (1974) found that age over 40 caused a 30% productivity fall in heavy road construction. Mather (1970) cites higher absences for older workers in engineering, and self reports of higher levels of fatigue by older clerical workers. Mark's study (1957) in footwear and clothing firms found only small productivity decrements after age 55 (of the order of 5%), a finding confirmed for furniture and footwear (1958).

(b) **Experience**

Some age effects may be proxies for experience effects. For skilled or managerial jobs, it may be hard to measure output and hence the result of experience. Conversely for less skilled jobs the experience effects may be of such short duration as not to be measurable. Kutscher and Walker (1960) found lower productivity for female clerical workers aged less than 25, which may reflect an experience effect. Medoff and Abraham (1979) found no evidence that, among male managerial and professional employees in four major US corporations, experience was associated with higher productivity ratings. See also studies of experience effects included with education studies, above.

(c) **Sex**

Mather (1970) cites Brouha that women have 25-30% lower aerobic capacity, and therefore lower maximal manual work capacity. He cites Patel and Grant on different learning patterns by sex. Attempts to use female earnings to measure relative productivity are dubious. The impact of passing equal pay laws, which reduced pay differentials within jobs, indicates that effects of tradition and non-economic considerations have had considerable impact on determining female earnings.

(d) **Race**

Eriksson (1974) finds that Thai road construction workers have the same physiological capacities as Swedes, once one removes the effect of past nutrition by controlling for body weight. Discussions of how differences in productivity are related to nationality focus more on motivation and different cultural norms and values, than on racial differences in abilities or work capacity.

(e) **Genetic and Psychological Factors**

Correa (1963) tried to separate heredity from environment using IQ correlation between children and true parents and foster parents, and concluded hereditary components were important. Aspects of personality are also important. Mather (1970) cites Hanes and Flippo (1963) that anxiety level affected muscular tests, and that psychotic patients did worse on step tests, an indicator of physical stamina.
Synergisms Among Quality Factors

One reason that it is hard to test the effects on productivity of improvements in labor quality, and which may also account for the diversity of empirical results, is that quality inputs act synergistically. The main interactions would seem to be between health, nutrition and education. Possible interactions between psychological factors and physical performance are not discussed here.

The synergism between nutrition and disease is well recognized (see Scrimshaw, Taylor and Gordon (1968) for references) but there has been little research focussing on adult productivity. The IBRD (1976) has quantified the cost of nutritional losses for infants from ascaris, for example, but the ultimate effect of ascaris on productivity is not known since the child nutrition-adult productivity relation is not quantified. Based on evidence linking childhood malnutrition to intelligence, Selowsky and Taylor (1973) made rather exploratory extrapolations into the impact on adult earnings for Chilean construction workers. For these workers schooling, unlike intelligence, was not a significant determinant of variance in earnings - perhaps because for this sample its level and variance were low. Usually, however, there will be a correlation between pre-school ability and years of schooling. Recent work by Selowsky has focused on this link (Selowsky, 1980). Disease and malnutrition will also directly impede learning, with eventual consequences for adult productivity. The effect of disease on motivation, causing apathy and listlessness and lack of perseverance and concentration, seems self-evident, but again quantitative estimates are lacking. Lower levels of disease and hence higher life expectancy may increase incentives to invest in human capital, i.e. education.

The effects of education on health and nutrition have been less emphasized. There is now, however, considerable evidence of the effects of the education of parents on the survival and nutritional status of their children (Cochrane et al., 1980). The education of mothers appears to be more important than that of fathers, suggesting that the effect of education is at least partly through behavioral change, not simply because education leads to higher incomes. There may be an even more indirect effect of maternal education via decreased fertility and consequently better child nutrition.

Sources of Productivity Differences: Motivation

Relatively few people work at jobs where they have no control over their own pace of work. In virtually no country is as much as half the labor force classified as industrial, and only a fraction of these work on assembly lines and whose quantity of output is therefore entirely machine-paced. Even on assembly lines, people often have control over quality of output. Ginzberg (1976) estimates that the assembly line prototype describes the working environment of less than 2 percent of all employed Americans. Glaser (1976) cites a 1973 US Gallup poll:
Could workers produce more? | Could you produce more?
---|---
Agree | 56% | Yes | 50%
Disagree | 33% | No | 47%
No opinion | 11% | No opinion | 3%

About 40% of those who felt that they personally could do better felt they would produce 30% more output, and a further 30% felt they could produce some 20% more. Those expressing more dissatisfaction with work were more likely to say they could produce at least 30% more output.

Glaser then cites a number of examples where striking improvements were obtained by changing job content, raising the perceived status of employees, or increasing their sense of participation. Among them, a medical company raised productivity by 32% over 3 months; a similar increase was obtained in a steel mill; both were under threat of closure. A pet food company found large changes in number of rejects and in absenteeism. One manufacturing firm making plastic packaging material found that changing job titles, content, and perceived employee status (e.g. discontinuing clocking-in systems) led to a 29% productivity improvement in two years.

Although Glaser also discusses a number of cases where attempts to improve the quality of working conditions to enrich jobs did not achieve their intended effects on productivity, absenteeism or labor turnover, it is clear that poor worker motivation can be a source of low productivity in the US, and there is certainly no reason to suppose that the situation is different in other countries.

Finding ways to motivate people to work harder or more efficiently might therefore be very worthwhile. Most economic discussions of labor supply are based on the assumptions that working harder entails greater disutility and that greater monetary reward is likely to bring forward greater effort. Eventually, of course, the effects of higher income on the demand for leisure and a desire for a more relaxed pace would cause the supply of effort curve to bend backwards; virtually nobody wants to spend his entire working life working flat out. The implicit assumption of most discussions of labor supply, however, is that most people are on a rising portion of their curve. It is therefore normally assumed that higher wages per hour will cause a worker to work longer hours, if he has an option to do so, and that piece rates will raise productivity compared with time payments.

Both psychological work on human motivation and work satisfactions, and empirical studies of alternative systems of compensation, suggest that these assumptions may be over-simple, sometimes to the point of being misleading. In the first place, work is a source of satisfaction as well as disutility, and this is true not merely for poets, actors and academics, but for office and blue collar workers as well. See, for example, the interview with the heavy equipment operator in Terkel (1972). Second, work is a social activity, normally performed in groups, and the response of an individual to a change in payment will be influenced by how this affects his
relationship to his colleagues, and its implications for his future dealings with his employer.

We discuss the psychological and social factors in turn, and then consider the empirical evidence on material and nonmaterial incentives.

**Psychological Factors**

Herzberg (1959, 1966) has developed a theory of attitudes to work that separates out the characteristics associated with any job into "motivation" and "hygiene" characteristics. The results were from a study of 200 engineers and accountants in Pittsburgh, who assessed their own productivity. Respondents, asked what gave them satisfaction at work, tended to mention a set of items that Herzberg calls "motivation"—such things as achievement, recognition, sense of responsibility, and pleasure from the work itself. "Hygiene" factors are such things as salary, working conditions, company policy and administration. These were mentioned relatively rarely as giving satisfaction, but were the principal sources of dissatisfaction. In contrast, absence of the motivating factors was relatively rarely mentioned as a source of dissatisfaction. It is possible to argue that Herzberg’s questionnaire gave too much attention to identifying particular high points of satisfaction and dissatisfaction rather than their general levels. Also that his sample was more educated and skilled than the average worker. However, his research places clear emphasis on the importance of intrinsic as opposed to extrinsic rewards from work.

Porter and Lawler (1968) tested how far pay was a hygiene factor and could not motivate performance, and how far a motivator factor which could by fulfilling needs for esteem and recognition. They related self and supervisor evaluation of performance to attitudes for managers in seven enterprises, and found that for those managers for whom pay was a satisfier, i.e. pay was seen as dependent on performance, were more effective and motivated. Further research would seem appropriate, to apply these ideas to developing countries.

If rewards are primarily intrinsic to the task performed, the provision of extrinsic incentives may have a perverse effect on performance. This has been shown experimentally with children. deCharms and Muir (1978) cite several studies. Children who enjoyed using felt pens, chose them less when the reinforcement of a "good player certificate" was added. Performance quality on tasks was found to deteriorate when TV surveillance or external deadlines were applied. Green et al. found that performance on mathematical activities deteriorated when an external reward was added, and deterioration was greatest on the activity originally most preferred. The implication is that if a task has been viewed as a highly skilled craft, heavy emphasis on quantity, implicit in the introduction of piece rates, may lead to a deterioration in quality. Psychological explanations for this are that an external reward mechanism produces a response interfering with the reinforced action (Riess and Sushinsky), or that the task becomes associated with delay in receipt of reward and is less pleasurable (Ross, Karriol and Rothstein).
The response to incentives may be affected by perceptions of value of the job. Wyatt in Marriott (1957) found that output when unwrapping candies was not increased by financial incentives as much as when wrapping, a seemingly similar operation: the former job was, however, seen as less useful.

Psychological factors are important, as found by Simonson and Weiser (1976) in studies of fatigue. Workers who scored high on an achievement-motivation scale found it socially unacceptable to admit unwillingness to continue on a task and would complain of fatigue instead, or project their own avoidance motive on to work mates. Studies of physical fatigue may therefore encounter problems if subjective fatigue is used to measure them. Simonson and Weiser cite Jarrard, that people told one of two identical weights was heavier, became more tired lifting it.

Social Factors

The Hawthorne studies (1939) found that separating one work group from others could raise productivity. It was an accidental finding of experiments with lighting, that productivity depended more on motivation. An earlier study by Mayo in a Philadelphia textile mill 1923-4 (cited in Gellerman, 1963) had found group motivation effects influenced productivity more than varying hours and rest breaks.

The size of work group affects strength of social relations, and appears to be important. Marriott (1971) cites his own study where in two car factories, productivity varied inversely with work group size. Productivity per man in work groups of all sizes was lower than for individual piece workers, except for those groups of two or three which could choose their colleagues. He also cites Shimmins, Williams and Buck who found that productivity in railway repair varied inversely with work group size and directly with group stability. Payment systems also influence social relations. Davison (1958) found that incentive payments caused a rise in tension in social relations.

Most people expect a continuing relationship with their employers; a response made to a change in the system of payment is going to be greatly influenced by the implications it might hold for the future. The Hawthorne experimentors found a negative skew to productivity variations across workers, which they argued was caused by output restriction. Workers set norms for an acceptable maximum output amongst themselves, since if management perceived that piece rates were too "soft," they would then restructure rates. Ratebusters or individuals who exceeded the worker-determined norms, were often subject to social sanctions. Roy, in Lupton (1972), reports on similar personal experiences. Working in a US machine shop, he estimated that he worked at 83% efficiency on average, 73% as he became more skilled, and 64% on easy jobs. He attributed a bimodal distribution of worker productivity to two effort levels. He observed that output restriction occurred on easy jobs so as to avoid rate cuts by management, and there was one effort norm
for these jobs, enforced by peer pressure. The other pattern was "gold-bricking" or a minimum possible effort on jobs where it would be too hard to achieve any bonus.

Argyle et al (1958) briefly survey evidence for social factors such as working with friends, and conclude that at most they can affect productivity by 7-15%, and argue that psychological factors can be more important.

Empirical Evidence with Material Incentives

Given its social and psychological complexity, it is not surprising to find that the empirical evidence on the effects of financial incentives on productivity is mixed. Marriott (1957) found only a 0.3 correlation between changes in earnings and changes in productivity. In addition to Marriott, Davison (1958), the ILO (1951), and Lupton (1972) also review evidence. Much of this derives from the experience of firms changing payment systems, usually simultaneously when other changes occur, though there are also a few controlled experiments. Marriott (1957) notes that of 79 schemes adopted between 1948-52 in the UK, 69 included changed methods. Thus studies do not isolate the effect of payment systems alone. Nevertheless, what follows is an indication of magnitude of some of the changes recorded. For firms changing the system of payment, Davison et al. (1958) found productivity changes from 7.5 to 291%, around half between 43% and 76%. Marriott (1957) cites an Australian survey in 1945 with a range of effects from 38-99%. The ILO (1951) cites three factories for the Netherlands averaging 36.5% improvement. The US War Board found an average of 41.5% improvement on 49 schemes, also cited by the ILO. The IBRD (1975d) found that changing from time rates to other piece rates or task rates improved productivity of Indian road construction workers by 50-75%. ILO road construction studies (1963) confirm this in Nigeria and Tanzania: when paid in such a way that workers felt they were working for themselves (the workers were self-employed as farmers the rest of the time), productivity improved. In India changing from a day rate to a finish-and-go system raised productivity 45-53%, to a paid task rate 60%. In general, results vary by the type of system adopted, and not all systems are applicable to all jobs. See ILO (1951) on this issue.

There is evidence of extensive failure too. Marriott cites the 1951 conference for Social Advancement of Management where of 316 plans surveyed, 78% failed completely or developed major weaknesses, and a UK Ministry of Labour report that of 915 schemes, 66% were discontinued.

Empirical Evidence with Non-material Incentives

Reference has already been made to the review by Glaser (1976) of the relations between attempts to improve the quality of working life and the intrinsic interest of the job and productivity. For example, a firm dealing with telephone and letter complaints found that quality of service and productivity improved significantly when job content was changed by vertical loading' (more responsibility) or horizontal loading (greater variety of tasks). Warr and Wall (1975) similarly rate several studies of job enlargement.
Salesmen given four areas of discretion (on selling prices, making settlements of complaints, on frequency of customer calls, and on whether to write a report) increased sales performance by 19% over 9 months, whereas controls decreased performance by 5%. Employees of a military organization servicing aircraft instruments improved quality of work and lowered cost, relative to controls, when jobs were enriched. In an Indian calico mill overspecialization by task was found to be less productive than allowing worker groups more autonomy. In producing radios, women employees changed from being responsible for small parts of component assembly, to production of entire radios. The number of sets without faults increased by over 15%.

Work standards have been another non-financial incentive. Marriott (1970) cites Mace's study of schoolboys doing a computation test, where setting a specific goal was found to increase speed more than either exhortations to surpass previous performance, or to "do one's best." He also cites Gibbs and Brown's study of repetitive document copying where monitoring output led to a 20-40% improvement in performance. This could be linked to psychological theories of role congruence, as suggested by Simonson and Weiser (1976), who found that people of high status would improve performance if told that their performance had worsened, even if it had not.

At times of crisis, appeals can be made for individuals to work harder or make sacrifices for the general good. This would be more naturally expected in a socialist society than in a capitalist one. China has experimented with the use of moral suasion, in an effort to develop a more socially conscious 'new socialist man'. Howe (1978) has written on the use of non-financial incentives in China. Rawski (1979) documents diminishing labor and total factor productivity in agriculture from 1957-75, although here pressure on land rather than motivation is probably important. Chinese economists such as Xue Mu Qiao and Hu Qiao Mu have discussed Chinese concern over slow productivity growth in industry in sources such as The Peking Economic Review. There has been a shift from the "iron rice bowl" policy of guaranteed employment and no financial incentives, to a system using piece-rates and similar incentives. Japanese experience with a high level of participation in decision-making and the building up of long-term loyalty among employees (Dore, 1973) suggests that employees with a great deal of confidence that they will be treated fairly in the long term may not need short-term material incentives to raise their productivity. Profit sharing schemes in this situation seem relatively more successful than in the US and Western Europe, in encouraging high productivity.

In this respect a recent paper by Oshima (1979) is interesting. He argues that there are different market value systems appropriate to different stages of technology. Labor habits or obedience to discipline are important at early stages of development when output is not machine-paced, but less important later as centrally operated machines become more important. He argues that the Confucian-based ethic in Japan was important for its early industrialization. Teaching appropriate attitudes to work has been an important part of formal as well as informal education from the earliest years. Western style work ethics suitable for advanced capitalism hindered development when introduced with colonialism into Sri Lanka, India, the Philippines, Indonesia and Indo-China, etc.
Sources of Productivity Differences: Management

Management affects labor productivity in a large number of ways, extending from setting general goals for the firm to supervising day-to-day tasks, and encompassing a wide range of allocation and technical decisions - such as the choice of product, the scale and techniques of production, the establishment of methods and conditions of work etc.

Unspecified management factors have often been held responsible for labor productivity differences with apparently similar techniques, especially for international comparisons where there were obvious national differences in management style. The Anglo-American productivity council surveys stressed this. Marriott (1957) cites Handyside's conclusions that management factors were crucial for US-UK differences. He also cites Murray's evidence for the shoe industry, where the UK had lower labor productivity despite a higher prevalence of incentive payments which Murray attributed to poorer quality management. Kilby (1961) blames lower African labor productivity on poor management rather than inherent worker quality, arguing that poor work conditions and lack of financial incentives cause low effort. Bruton's (1967) work on slow Latin American productivity growth is part of the large literature on harmful effects of import substitution policies, which decrease foreign competition and therefore allow slack management.

Goals of the Enterprise

Several theories have emphasized management objectives other than the maximization of profits, e.g. maximum growth (Marris, 1964), sales (Baumol, 1959), managerial discretion (thicker office carpets -- Williamson, 1963). In that case, they need not aim for maximum factor productivity, although maximum productivity may in some cases further these other goals.

Theories of organizational behavior seem more promising in explaining factor productivity variation and apparent inefficiencies. Cyert and March (1956), and Simon (1959), look at the cost of information and making decisions in building bounded-rationality models of the firm, e.g., using satisficing decision rules. Leibenstein (1969) incorporates personal goals separate from the firm's, e.g. agent-principal relations, interpersonal conflicts of interest, personal aims to minimize external pressure or authority. He develops a theory of X-inefficiency where firms may end up in an "inert area" with suboptimal outcomes. Leibenstein (1979) has a valuable review of organization theories.

Arnold recently reviewed psychological theories of organizations, in Meitel and Meltz (eds) (1979). He cites Lindblom's theory of "muddling through," where organization structure determines the method by which decisions are reached. Ill-adapted structures can lead to suboptimal decisions. Psychological theories underlying management behavior are related to those underlying worker behavior, and much of the discussion of worker motivation applies also to managerial motivation. For workers it was hard enough to
measure values and performance, and for managers it would seem even harder. For workers at least there is substantial research on payment systems; for managers most work goes little beyond vague references to disincentive effects of high taxes.

An important exception is the work of McClelland (1966, 1969). McClelland developed the concept of "need achievement" - an attempt to quantify a set of attitudes that provide the drive needed for entrepreneurial success, and also high work motivation. Such attitudes are related both to national attitudes to success, which is determined by prevailing social and cultural values, and to individual striving for success. For a nation, n-achievement could be measured by making a content analysis of imaginative thought. "N-achievement" has been separated into fear of failure and hope for success and even (female) fear of success. McClelland has extended his work to a power motive and there have been other extensions of his idea. Raynor in deCharms and Muir (1968) developed the concept of future orientation, where actions are seen in the context of a series, not as isolated events. This leads to predictions such as that performance is better if steps in a long contingent path are seen as easy rather than difficult. Other attitude scales have been developed, some emphasizing more cognitive aspects, others measuring such things as alertness and task avoidance.

Although this work has not been taken very seriously by development economists, it does have two attractions. First, in explaining differences in economic performance in different circumstances, it does advance hypotheses that are testable in a way that some explanations advanced by economic historians - for example, the Protestant work ethic, Buddenbrooks syndrome, Hindu fatalism, Chinese industriousness - are not. Freeman (1976) for example finds "n-achievement" to be significant in cross-country production function regressions. Tekiner (1980) likewise performs international correlations of income growth rates and average propensity to invest, both for the whole economy and the private sector, each separately with need achievement. Correlations for absolute levels of "n-ach" and economic variables for 1953 for 25 developed and developing countries were not significant, but were so in first difference form. However, the very small sample size (as low as 9 countries in some cases) and the lack of attempt to control for any other variables known to affect country growth performance, makes the results unreliable.

McClelland and Winter (1969) survey other empirical tests. Rogers and Neill for India and Colombia found a correlation between n-achievement and agricultural innovation. Sheppart and Beliksky found that laid-off blue-collar workers with higher n-achievement were more likely to check into the possibility of re-employment, and Levine found a correlation between n-achievement and different economic motivation between the Ibo and Hausa tribes in Nigeria. Thus n-achievement can affect worker as well as manager quality.

The second attraction is that McClelland argues that values and attitudes can be changed even in adults. His 1969 study reports on some experiments in attempting to raise the need achievement of small businessmen
in India. Comparing the performance of managers who did or did not receive the training course, he found a significant difference according to manager attitude. Having taken the training course was correlated with starting more new activities, longer hours, larger increases in investment and number of employees. A problem with such an experiment is that people prepared to devote time to management and entrepreneurial training may already have atypical need achievements, and thus the effect of training is overstated.

Scott (1975) provides brief summaries of many behavioral theories relevant to management. Most appear less open to quantification than McClelland's, or less suitable for explaining cross-society differences, or for experimental testing. Most behavioral theories rely on case studies of individuals and groups, to discover behavior patterns, often with the aim of teaching others to adopt successful patterns. For example, Coverdale (1974) developed the "systematic approach" for thought patterns which he uses in management training. Similarly Blake and Morton (1964) developed a "managerial grid" cross classifying management style into "concern for people" and "concern for production." The main practical utility of most of these approaches would be in firm-level efforts to improve productivity.

Worker-Management Relations

(a) Supervision

The IBRD (1975d) studies of road construction in India found "good" as against "fair" supervision could account for a 33-125% productivity difference, and "good" as against "poor" for 91%. Marriott (1957) similarly cites case studies from the Michigan Institute for Social Research by Katz, Maccoby and Morse, and Katz, Maccoby, Gavin and Flore on the productivity effect of better supervision in clerical and railway work respectively. Better supervision seemed to be employee rather than production centered, as regards supervisor attitude. Subsequent work by the Michigan Institute, by Vroom and Mann, and by General Electric (cited in Gellerman, 1963), found however that appropriate supervisory style depended on the job and on the individuals supervised. An experiment by the Michigan Institute found clerical workers on whom production-centered supervision was imposed increased productivity by 25% over a year, as against 20% for a group with employee-centered supervision. This went against the earlier studies which favored employee-centered supervision.

Argyle et al (1958) tested supervision as a factor in productivity, for 90 working groups in one firm, using manager ratings of workers and in some cases direct productivity measures. They made a "human relations" score for supervisors, consisting of how far they exerted general, democratic and non-punitive supervision. This was found to be related to productivity, but more so in departments where an incentive payment scheme did not operate, and work was not machine-paced. Foreman training did not affect productivity, nor size of work group.
Page (1979) tried to use number of supervisors as a quality management indicator, arguing that fewer workers per supervisor might lead to tighter management and higher worker productivity. The opposite was found to be true, possibly because more skilled or disciplined labor required less supervision.

(b) Industrial Relations

Longitudinal firm studies by Marriott (1957) point to management-worker relations as being very significant in the success of payment-by-result systems, discussed earlier. Glaser's study (1976) of the effects of worklife improvement suggested that management sensitivity to worker needs would lead to large productivity improvements. See Stokes (1978) for further references. Different worker-management relations are often seen as important in explaining international productivity differences, e.g. poor UK productivity, though in this case it is hard to isolate the effect of industrial relations alone (see, however, Pratten 1976 a and b and the Central Policy Review Staff, 1975).

In general one would expect that workers would be more easily able to resist the introduction of new technologies and/or to insist on retaining obsolete job demarcation after new techniques were introduced in industries which are relatively less subject to foreign competition. Newspaper printing in Great Britain is notorious. However, the British car industry also suffered very substantially from over-manning (Central Policy Review Staff, 1975).

There are no wholly satisfactory ways to measure the quality of industrial relations. Firm size may change these relations due to greater employer-employee distance, but there may be offsetting effects on productivity. The number of strikes or grievances may be an indication of the nature of worker-manager relations, but not a good index of quality: a rising number of grievances, for example, might indicate a growing faith in the grievances procedure or confidence that managers will act on them, rather than worsening relationships. Most studies looking at the relationship between industrial relations and productivity tend to be across firms, or of one firm over time. There are some cross-country studies but they tend to be inconclusive since other conditions differ. Dore (1973) compared a UK and Japanese electronics factory with different productivity, and pointed out many differences in management style which might contribute. A different work ethic of managers is often invoked in UK-German comparisons.

Across firms, Page (1979) found that manager nationality was important in productivity in Ghana whereas owner nationality was not. The difference might partly be due to training and experience, but possibly also the attitudes of managers.
Worker Participation

Rosenberg and Rosenstein (1980) made an empirical study of the effects of worker participation on productivity. They regressed several productivity measures for 6 years for a US manufacturing firm (plumbing industry), on an index of five measures of worker participation obtained from analyzing minutes of worker meetings. Results suggested that worker participation variables accounted for 46% of the explained variance in productivity, and the authors suggest this was of greater importance than an incentive plan. However, they did not control for any other variables, and hence test whether correlation was in fact spurious.

Cable and Fitzroy (1980) utilized production function regressions for a sample of 42 German firms. They regressed value added on labor, capital, and existence of an incentive scheme, separately for firms with high and low participation, as obtained from firm-level questionnaires. The firms with higher participation had 28% higher marginal productivity for white collar labor and 15% lower blue collar. Incentive schemes had more impact on productivity in higher participation firms, suggesting participation and incentive schemes interact. However, participation might be a proxy here for several management variables, given that high and low participation firms had very different capital-labor ratios and different economic behavior.

The Choice of Product, Scale of Production and Degree of Integration

A study by Cole et al (1960d) of four British electrical factories is a fascinating examination of the effect of management decisions on productivity via product choice and methods of work. The four factories found different solutions to the problem of how to produce a varied range of electric motors while achieving scale economies in production. One used a few basic designs and tight supervision to achieve high average productivity, also using high quality labor. Another used abundant machinery and good maintenance to achieve high labor productivity, by avoiding wasted time. Another combined a single basic design with high productivity, with much custom work with low productivity to achieve a range of products. The last used low quality labor, slack supervision and no incentive payments. Consequently it had the lowest labor productivity, but since it paid low wages, it did not necessarily have higher unit labor costs. It would be interesting to repeat such a case study on work methods and product choice. Cole et al. surmised that productivity trends over time, as well as levels, might vary by work method chosen. No resurvey was done, but a combination of a cross-section firm study with a longitudinal study might be an interesting future research topic.

As this example illustrates, the choice of product or market size cannot be treated as exogenous in productivity discussions. Pratten's work (1976a) on product choice argued that lower UK productivity, relative to matched Swedish firms, was partly due to lack of product standardization. This he attributed partly to more varied UK tastes, but partly to less careful
management. Swedish companies specialised in high quality, technically sophisticated products produced at relatively high rates of output. Compared with the UK, much more of the overseas investment of these companies went to secure markets for these products.

Lamyai, Rhee and Westphal (1980) are studying in detail the effects of alternative processes used to manufacture components to assemble into bicycles in Korea. Processes use capital and labor inputs. The more specialised the input, the lower probable unit cost when the input is used at full capacity. However more specialized inputs might more frequently be idle, since they have fewer alternative uses in other processes. Thus the task of management is to perform a complex optimization process, over a large number of processes, to minimize cost. Lamyai et al. use linear programming methods to find the size of possible "economies of specialization." They find that economies of specialization owing to improved production organization appear to be at least as important as economies of scale resulting from increased output. Their method requires very detailed information, but is potentially a way of objectively measuring management performance.

A high degree of virtual integration may impede the achievement of economies of scale in individual processes. Baranson (1969) argued that in the automobile industry in Latin America, the higher degree of integration was an important factor causing lower productivity. In this particular industry, integration was necessary to obtain components of satisfactory quality. In some cases, however, vertical integration is pursued by managers for their own reasons, possibly to the detriment of productivity.

Increased scale does not necessarily mean greater efficiency. Studies of small-scale enterprises by Ho (1978) in Taiwan and Korea, and Page (1979) in Africa, found no effect of scale on either labor or total factor productivity. This might be used to estimate managerial quality effects as well as pure technical scale factors. Larger enterprises might have access to better quality managers through a higher ability to pay and to utilize people of different skills. On the other hand small firms might be directly supervised by the entrepreneur with more direct motivation. Also the small firm population is a heterogenous mixture of older firms, which may survive by serving localized markets inefficiently, and some new efficient firms which are growing larger.

Meller (1977) used Farrell's technique to estimate efficient frontier for different size classes within Chilean industry. He found frontiers did not move inwards monotonically with firm size, and therefore found no evidence of scale economies. Smaller firms were, however, on average further from the frontier appropriate for their size class, which suggests they included a larger fraction of firms with poor management. This would seem to confirm the argument above, that the relation of firm size and managerial quality is not determinate, but that smaller firms are a more heterogeneous population with more variance in managerial efficiency.
Sveikauskas (1975) looks at the effect of market scale on value added per unit labor, comparing 14 industries across US cities. He found doubling city size could increase productivity 5.98%, which may be a substantial amount considering city sizes double eight times between the smallest SMSA’s and New York SMSA. A time series study, found that doubling population could increase productivity 6.4%. He attributes the productivity differential to dynamic externalities. He controlled for capital-labor ratio and education, but no other factors, which may qualify the findings somewhat.

Choice of Technique

(a) Capital-Labor Ratio

Most of the discussion of inappropriate capital-labor ratios, begun by Eckaus (1955), generally argues that LDCs use relatively too much capital. If too high a capital-labor ratio leads to underemployed labor, this may imply either inappropriate firm decisions on factor use, or else that market prices do not accurately reflect relative economic scarcity.

Hirschman (1958), however, hypothesized that more capital-intensive techniques may be appropriate for developing countries, since capital can substitute for scarce managerial skill. Machine-pacing of an operation can substitute for tight supervision and ensure more uniform quality and higher rate of output i.e. mechanization may be labor-augmenting.

Daniels (1969) did find that more capital-intensive industries in Argentina were more efficient relative to their US counterparts, although his index of labor intensity (wage share) is appropriate only under certain assumptions on technology. Clague (1970), for Peru, uses Hirschman’s definitions of latitudes (of pace of operations, of work quality, of work schedules, and of importance of maintenance, where latitude industries tend to be less mechanized) and finds that “latitude” industries do in fact tend to be relatively less efficient. However, for Kenya, Pack (1974) found no correlation between capital intensity and the probability of firms being on the efficiency frontier. Mason (1971) cast doubt on the common view that the greater capital intensity of multinational subsidiaries led to their greater productivity. He compared matched pairs of foreign-owned subsidiaries and local firms, and found no significant difference on capital-labor ratio for Mexico and the Philippines, although the composition of capital differs.

Flamm (1979) looked at multinationals as against local firms in Mexico. He found that in some industries, such as chemicals, radio, TV and audio, firms used the same technology, but that multinationals had a higher capital-labor ratio. This was attributed to lower costs of capital for multinationals. This did not seem to affect total factor productivity. However, in one industry, printing, there seemed to be technical duality, with similar inputs but higher output and wages in foreign-owned firms. This was not explained in the study, although its implications for barriers to entry were pointed out.
Gouvernor (1971) argues using evidence on relative labor productivity for the same industries in the Congo and Belgium, that it is not machine-paced (process-centered as against product centered) industries which are relatively more productive in developing countries. This is because even in a process-centered industry there are many operations not amenable to machine pacing. He argues that it is degree of mechanization which affects labor productivity.

White (1976) in Pakistan found that capital-production labor ratios did not have as great a variance as capital-nonproduction labor ratios, for the same firms. The latter did depend on competitive variables such as proportion of output exported and industry concentration ratio: i.e. weaker competition could allow managerial slack, and in this case, overmanning in ancillary labor use.

(b) Labor Skill Mix

It has been found that, for the same industries, there are national differences in labor requirements in specific skill categories and also within single countries for the same industries, between locally owned firms and multinational subsidiaries. This implies different labor productivities by class of skill.

Mason (1971) found, for Mexico and the Philippines, that multinationals used relatively more technical and executive staff, and more semi-skilled and unskilled production labor than local firms. Multinationals may be able to draw on parent management and supervisory skills. They therefore employ fewer people in these categories, an area where LDCs have relative scarcity of labor. Because of better supervision, multinationals could utilize less skilled production labor. Local firms needed more managerial and professional staff and needed better quality skilled labor to substitute for the shortage of supervisory skills. Skill scarcity thus determines the pattern of labor substitution, and consequently relative productivity by skill class. Productivity of the scarce labor skills would be higher than that of more abundant categories which were being used as a substitute.

UNIDO (1968) similarly surveyed personnel requirements in detailed industries by country, and found systematic differences in the skill mix used. However, differences in the mix of skills were interpreted in a rather different way. The study assumed that there were substitution possibilities between labor of different skills, and that countries used labor of relatively high productivity more intensively. Thus relatively higher usage of a particular skill group was assumed to imply relatively higher productivity. For example, it was argued that the high use of clerical labor in India indicated the high productivity of such labor in relation to its wage. Direct productivity figures would be necessary to decide this debate, although this may be hard to measure where there are complementarities among labor of different skills.
Technical Efficiency

Having selected the pattern of output, and chosen the technique, factors of production still must be deployed efficiently. Most studies of technical efficiencies make cross-firm comparisons, using Farrell's (1957) technique. Page (1979) studied three industries in Ghana and found technical inefficiency to be more important than allocative efficiency in three Ghanian industries. In consequence he argued that the stress normally given to inappropriate factor proportions is somewhat misplaced, although managers who allocate inefficiently also tend to be more technically inefficient. He looked at proxies of managerial quality. Prior industry experience and formal training raised efficiency whereas the age of the firm did not, since it only imperfectly captured managerial experience. Older industries (sawmilling and logging), where managerial experience might be greater, were more efficient than newer (furniture). Tariff protection in the latter could have allowed managerial slack.

Shapiro and Mueller (1977) measured technical efficiency of cotton farmers in Tanzania and correlated it with many farmer modernity variables. In explaining productivity in cotton growing, they found that a general modernity index and an index of awareness of prices, were more important than actual knowledge of cotton techniques: i.e. they seem to have captured a quality index for management. They also found that management quality augmented labor rather than land productivity, which was not surprising since labor was the limiting factor to expansion.

(a) Work Methods

The IBRD (1975d) study found that simple changes in work methods in Indian road construction - altering the phasing of different tasks - if accompanied with incentive payments, could lead to 200-300% differences in labor productivity, of which incentive payments alone could account for 50-75%. However alert supervision was necessary to prevent reversion to traditional, less efficient methods. The ILO Philippines road studies (Lal, 1978) similarly found quite large productivity improvements could be obtained from changing work methods.

Changed work methods in a cotton mill in Britain during 1945-7, following a report of the Platt Mission which had visited the US, led to a productivity increase of 39% (Cotton Board, 1948). Part of this may have been due to the introduction of incentive payments. The changes included re-arrangement of duties of the operatives, rearrangement of layout of machines, and more machines per worker.

(b) Physical Work Environment

This literature is somewhat ad hoc. Worker performance in jobs requiring different skills does not respond the same way to physical conditions. Temperature and lighting for example, affect performance of manual and nonmanual tasks differently. Theory is limited - it seems too difficult
to measure fundamental job skill needs and worker skills and hence generalize research across jobs, although progress has been made, such as Chamberlain's work (1976) reducing educational skills to two human capital "factors". Empirical work consists largely of intervention and cross-section studies in individuals, often imperfectly controlling for other factors, and, since they tend to be studies of narrow tasks, are of unknown generality.

Mather (1970) cites evidence that noise and music can affect performance, which would be relevant to factory occupations. Open-plan versus conventional offices may affect productivity differently. Dust, lighting, and fumes can affect performance. Laboratory tests cited by Mather showed only small effects, but work environment may over a long period have a more marked effect, especially if it influences morale. The ILO (1951) found that minor changes in environment could alter productivity. For example, a better arrangement of workplaces in a German chemical factory could raise labor productivity by 60%; the shape of benches in a Swiss food factory raised it by 30-40%. Systematic arrangement of tools made a difference in 100% in textiles; while Ohio State University work methods studies of industrial tasks showed that rationalization of movements raised productivity by 60-600%.

Erikkson (1974) cites Wyndham, that a rise in temperature change from 25 degrees centigrade to 27.5 degrees centigrade cuts productivity by 5%, and to 32 degrees centigrade by 30-40%. This was obtained from laboratory experiments on manual tasks. However the effect differs by race, adaptation, type of clothing, and type of work. Mather (1970) cites Ward, finding that a combination of mental stress with heat and humidity can worsen the performance on mental tests, by more than physical discomfort alone. For outdoor tasks, climate is obviously not under management control, although scheduling tasks by time of day may be one way for management to influence productivity. However for people working indoors, management can affect productivity.

(c) Hours

There is evidence of a relationship between hours worked and productivity. Evidence of a relationship goes back for many years, and was frequently cited when legislation on shorter hours was proposed. Webb and Cox (1891) describe early evidence on hours reduction. They found wages seldom fell as a result of hours reduction, but only cite one direct piece of evidence on productivity. This was in chemical manufacturing, where a reduction from a 12 hour to 8 hour day with weekly earnings per worker unchanged did not increase cost of production, implying a productivity increase. Brentano (1894) cites experiments done by cotton manufacturers before the passing of the Ten Hours Act. The manufacturers found a reduction from 12 to 10 hours caused daily output to fall by one-twelfth, not one-sixth. In addition to this, it was found that "just in those last two hours a good deal of material was spoiled by the weary and therefore careless operatives" (P. 29.) He cites Chamberlain's evidence for mining where a 17% hours reduction from 12 to 10 hours reduced production only 8%, and a further 10% hours reduction from 10 to 9 hours, reduced production only 5%. The Industrial Health Research Board inquiries in Britain from the 1940's had similar findings.
The exact relationship is, however, hard to determine. Mather (1970) finds mixed results for sleep deprivation studies, depending on the task. Lack of change of total output is sometimes recorded when hours change, which indicates that conscious output restriction must be controlled for. Psychological factors are very important. Mather cites a finding of Walster and Aronson that people who expected a task to continue longer were less fatigued after the same work time than those who expected the task to terminate shortly.

Breaks improve productivity, and Mather cites the beneficial performance effects of physical exercise during breaks for post office workers. Ribeaux and Poppleton (1978) cite the findings of Miles and Skilbeck, that the introduction of two fifteen minute rest periods for production workers in a US firm increased productivity by over 15%. They also cite the findings of Bhatia and Murrell in the UK, where productivity of female operatives remained about the same when an eight-hour work day was reduced to seven hours by interposing rest periods.

Time of day affects productivity, due to the existence of Circadian rhythms. Colquhoun (1975) discusses laboratory tests where performance on six tasks depended on time of day. Further experiments involving the Navy examined the effect of varying and rotating shifts. He also cites field data from Sweden, where number of errors reading gas meters depended on time of day, and from Germany, where frequency of errors (compulsive brakings) by locomotive drivers also depended on time of day. Farooq (1977) finds that in advanced countries, night shifts do not have lower productivity than day shifts, whereas in LDCs lower productivity occurs. Baily (1974) found it could be as much as 50% lower in Kenya. Farooq argues that self-selection operates — in advanced countries, the night shift premium causes the workers most tolerant of night work to choose night shifts. In LDCs, the scarcity of jobs bids away the shift premium, and prevents self-selection. Since night productivity is lower, the output of night shifts is more expensive. This discourages them and, paradoxically, contributes to a lower utilization of scarce capital.

Problems and Priorities for Research

It would be extraordinarily presumptuous of us to try to cast judgments on the results of this vast and highly diverse body of research, undertaken over a long period within the framework of several disciplines, and with greatly varying purposes. No doubt there is ample justification for the humblest time-and-motion study, and for the crudest cross-national comparison. If, however, we focus on the concerns which originally prompted this survey — research carrying implications for policies that might raise labor productivity in developing countries — some conclusions can be drawn both with respect to the deficiencies in the current stock of research findings and the directions that future research should take.
It should just be noted that macro and micro studies are measuring rather different effects. The greater the level of aggregation used, the more of the allocational and externality effects will be captured, and one would thus expect larger effects to be measured. This to some extent may explain why the studies of management and motivation, which tend to be at firm level, show much larger effects on productivity than the studies of labor quality which are often at individual level. It also may explain why the intervention and individual-level studies of labor quality find much smaller productivity effects than macro level studies of labor quality. Conversely, however, the more aggregated the level of the study, the less easy it becomes to control for other factors, and the less easy to attribute productivity change to the variable being studied.

Macro-Level Comparisons

Comparing the levels and growth in the average productivity in large geographic aggregates - mainly, but not necessarily, countries - is an irresistible, harmless and, to some extent, instructive pastime. In the first place, given the close association between the growth of productivity and growth of incomes, productivity growth is an important indicator of economic performance. Moreover, given the complexities of the growth process and the many influences on productivity, the overall picture only emerges from cross-national comparisons. Such comparisons may suggest some broad explanations - culture, national economic management, levels of investment, which can subsequently be turned into testable hypotheses.

Although some of these hypotheses can be tested at a macro-level, there are considerable difficulties in using this approach to derive firm conclusions about the determinants of productivity. First, there are theoretical objections to going from the production function for an individual product to an aggregate one, even within one economy at one point of time, let alone across countries or over time. Second, national averages may conceal a great deal of individual variation. Third, most macro-studies attempting to look at the effects of one policy variable - for example, health on productivity - have encountered problems of simultaneity. Health improvements may increase GNP, but rising incomes will lead to increased expenditures on health, independent of any productivity effects. This may make the apparent contribution of health to economic growth appear greater than it has been. Fourth, some variables - for example, education - can affect productivity only with a considerable time lag, but this is not always taken into account. Fifth, expenditure is also a far from satisfactory measure of inputs - it is much better to use carefully chosen physical indicators, such as the number of drinking wells or physicians (assuming one can control for quality). Similarly in aggregate studies, output must be in value terms rather than in physical productivity, which would be conceptually more satisfactory, but is usually impossible for reasons of heterogeneity and differences in quality. Sixth, it is methodologically un-sound to correlate a health output measure such as mortality and an economic output measure, and infer causality. Lastly, since economic development, human resource development, and productivity are highly correlated, it is hard to assess direction of causality.
Nevertheless with careful specifications, simultaneous equation techniques and access to sufficient data either over an adequate time period or from a sufficiently diverse cross-section, it is possible to derive interesting results from this approach. One such example is the recent work of Wheeler (1980). But the valuable features of Wheeler’s work will make it difficult to follow in the same genre, at least until the experience of several more years exists to be compared. Although to some extent one can experiment indefinitely with different equation specifications, perhaps obtaining rather different interpretations, this would not necessarily bring further insight. Most further progress is therefore likely to come from research at the level of the industry, firm, or individual employee.

Micro-level Studies

(a) Labor Quality

At the other extreme from the macro-level studies are those which derive conclusions about productivity from the analysis of differences among individual workers. This can allow for a much sharper testing of hypotheses about the determinants of productivity. In principle we can use direct measures of output per man, rather than simply earnings, and more refined measures of inputs – e.g. instead of simply using ‘years of schooling’ as a proxy for education, we can also use test scores, indicators of school quality, etc. In practice, however, we have come only a little distance along this road, and have already encountered considerable difficulties.

(i) Output Measures

Direct measures of worker output in most occupations are difficult to obtain. They are most readily calculated in agriculture, and in manual labor that is not machine-paced, such as construction. In agriculture, production functions can be estimated in physical terms, since there are usually a limited number of reasonably homogeneous inputs and outputs, especially if the farm is small with little joint production. Similarly there may be records for workers paid by piece rates in other occupations. For individual construction and other activities it may also be possible to derive physical output measures by observation. However, as noted, the simple effects of being observed can have a striking impact on output.

For most industrial occupations it is harder to get direct productivity measures. The use of supervisory evaluation has been criticized. This is the only feasible measure for many nonmanual jobs and hence has several times been used when trying to assess the effect of education. It has been argued that subjectivity makes such assessments arbitrary, or that the ratings measure promotability rather than productivity, since supervisors want to seem justified in their ratings. Different yardsticks may have been used. For example, in the case of experience it has been argued that the more experienced are rated against a tougher standard and that therefore ratings conveyed no absolute information. Medoff-Abraham (1979) refute these criticisms fairly convincingly.
(ii) Input Measures

There are also difficulties in getting sharp, policy-relevant measures of inputs. We need first to be able to associate key elements of worker characteristics, especially those amenable to policy manipulation, with different levels of productivity. We need, for example, such things as good measures of the educational, nutrition, and health status of workers. Other research may then suggest how to bring about changes in status.

Collecting this sort of information is likely to be comparatively expensive. It might involve collecting measures of knowledge and attitudes, heights and weights, hemoglobin levels, and lung capacity, and giving stool and other tests. Compared with other survey research, it is likely to require more intensive training and more equipment. There are examples of research involving all such measures, but more is clearly needed. Before embarking on such research, however, clearer understanding of the processes likely to be involved and hence on the measures to be needed is required.

For example, consider research relating education to productivity. The impact of education on productivity may be via literacy, via numeracy, via screening, via various affective traits, via analytical skills, innovative skills, etc. The particular route may well be different for different tasks in which productivity is measured. Are there intervening variables in these causal chains which would make appropriate proxies for amount of educational input? For example, numeracy rather than literacy is believed important for managers of small enterprises. This could be directly tested, rather than assuming that an arbitrary number of years of education are needed to confer literacy. A useful distinction could be made between formal and nonformal education. These confer different skills, and have different effects. The managerial studies suggest that LDCs do not necessarily lack educated manpower (as witness educated unemployment in many countries), but rather lack specific skills such as supervisory capacity. Such skills need not best be taught by formal education. Fuller (1972, 1976) found on-the-job and informal vocational training increased market productivity. Research into nonformal education such as OECD (1978), and work of Michigan State University's Center for Non-Formal Education, appears only to have studied effects on earnings rather than direct effects on productivity.

The education-earnings-productivity-promotion linkages further illustrate the need for a clearer understanding of causality. Certain types of education seem to increase promotion, some productivity. The impact on productivity, which had been thought to have been implied by earnings, turns out to be difficult to substantiate, indicating possibly that some component of education may increase productivity and a different one earnings.

Similar issues arise for nutrition. Moreover, since economists tend to be unfamiliar with health and nutrition fields, it remains to be fully realised that "health" and "nutrition" are not unidimensional measures, capable of being reduced to a single scale. Different diseases affect different abilities and sometimes permanently, sometimes temporarily. Nutrition
affects the availability of calorie stores to be used as energy. This is likely to put a long-run constraint on energy used in paid work. It is less likely to affect productivity. Physiological studies suggest productivity depends on maximum work capacity, and the percentage of maximum sustained. According to Viteri (1971), maximum capacity depends on maximal aerobic capacity and level of anemia since these determine oxygen supply to muscles and hence the rate at which food energy stores can be converted to work energy. Nutrition changes body composition and hence, aerobic capacity. Anemia levels depend on iron intake, and so nutrition affects the rate at which work energy can be obtained from the body and therefore productivity.

Height is tenuously correlated with aerobic capacity as both depend upon past nutrition, but height varies less than weight, and unlike weight a worsening of nutritional intake cannot decrease height. Also genetic effects are important. Height is therefore an imperfect indicator of long-run nutrition status, and it is surprising to find it is significant in Immink’s (1978 b) and Spurr’s (1977 b) studies. Weight is more sensitive to recent nutritional history but is also genetically variant and is not perfectly correlated with lean body mass, which Viteri argues determines aerobic capacity. Weight for height may remove some genetic effects, but is likewise imperfect. Hence negative results in studies by Popkin and Basta are not surprising, since the measures of nutrition used were imperfect. The effect of weight of Indian industrial workers being significant in some studies relating productivity to weight, seems to be because weight and lean body mass were closely correlated (Satyanarayana, 1977, 1978). Hence, testing the relationships between nutrition and maximum work capacity requires an appropriate measure of nutrition status, and control for iron level.

To go further and measure relationships between nutrition and productivity, one also needs evidence of the effect of nutrition on percentage of maximum work capacity sustained while at work. There is little evidence about this, since it requires measurements such as respirometry during actual work performance. Nutrition may also affect percent of maximum that is sustained. For example, Viteri found that malnourished peasants become more exhausted over sustained tasks. Possibly the finding that nutrition can affect productivity of older workers occurs via this channel, since it is unlikely to affect maximum capacity.

In short, to obtain nutrition-productivity evidence may also require more careful study of the physiological channels, and of which physiological measures are appropriate.

Similarly for disease, it is unclear as to whether disease affects maximum physiological capacity, or percentage sustained in work, or both. The type of disease and its severity may affect maximum capacity and sustained capacity differently. Chronic respiratory diseases definitely impair lung capacity, and therefore maximum capacity. Other diseases may work by reducing effort intensity or length of time for which effort can be sustained.
Most research involving measurement of disease use crude measures. For schistosomiasis one needs to measure the severity of infection. The simple infected/not infected dichotomy is insufficient as there seem to be nonlinearities and threshold effects. Weisbrod’s (1977) measure (presence of parasitic infection at one point in time) is a very imperfect indicator of disease status over a period. It is perhaps not surprising that current productivity was not strongly related to disease status as he measured it, and that later productivity on a banana plantation was not found to be related to disease status two years earlier.

(iii) Issues in Research Design

In general considerable care needs to be taken in research design. Since there is evidence that the effects of education on productivity are likely to be greatest in situations of changing technology, the absence of such effects in a study which correlated engineering firm productivity and skill level of labor force in an industry with stagnant technology is not surprising. There have been few if any studies investigating the impact of nutrition or disease when technology changes. The allocational and externality effects may be much more important than productivity effects within heavy manual labor.

In nutrition experiments Basta (IBRD, 1974) tried to control for motivation by holding races: the result was that motivation was so high that weeder workers were exhausted after a one-hour race, and this was not a long enough period to detect a productivity difference. In Satyanarayana’s (1972) study of miners’ output the availability of machinery limited output. Ninety four percent of the workers receiving food supplements surveyed said that they could have worked more; the unsupplemented were not surveyed. It is not unsurprising that no productivity effect was observed.

Experiments with single quality indicators of labor may not control for other indicators. As we have seen, however, synergism may be important. For example, the effect of a nutrition intervention may be very different according to levels of disease. It may operate on productivity indirectly through a variety of channels. Viteri (1971) found that supplemented workers were more active out of work, and several intervention studies found no rise in work output, but maintenance of energy balance by workers occurred which implied higher out-of-work energy expenditure. This may have indirect productivity effects, measurable only in the longer run, e.g. greater energy expenditure in sports builds up muscles or raises lean body mass and improves maximal aerobic capacity. More free time leaves more time for education, or for cultivation of one’s own land which improves family nutrition and provides variety to diet which can reduce disease. The supplementation of one family member’s nutrition may therefore have complex and long-run effects on productivity, time allocation, education of the entire family. Large scale studies working at several indicators of labor quality simultaneously may help. Time allocation surveys may also be a valuable adjunct to such research, to test whether there is an intrahousehold reallocation of tasks. This may be a way to estimate and understand the external and allocative effects of various interventions rather than relying on macro-level analysis.
More careful attention to the mechanism of effect of labor quality factors may be necessary, whether it is via worker, allocational or externality effects, whether direct, indirect, or synergistically via other inputs, and through which abilities it affects productivity. Without such attention it may continue difficult to trace at the micro level, effects which seemed large at the macro level.

One of the most serious research difficulties for micro-level studies are biases introduced by "self-selection" in the sample. Suppose one wants to look at the productivity effect of education by comparing productivity within a single occupation or grade. If the workers with most schooling who have not been promoted out (because they lack other abilities) are compared with those with least schooling in the grade (who may have unusual personal attributes) then it may erroneously appear that productivity and education are unrelated. This may explain why Fuller, and Deraniyagala, do not find an effect of education or training on productivity.

The importance of selection bias in education studies is now well recognized. Heckman (1979), Griliches et al. (1977) and others have developed techniques to remove unmeasured ability factors. The importance of this bias in health studies is likely to be as great, but has not fully been taken account of, e.g. if taller cane cutters are more productive (Imminik, 1978 b) then small men who remain as cane cutters may have some unmeasured characteristic (stamina, resistance to heat) in greater amounts to compensate. Thus ignoring the selection effect means that the effect of height alone is underestimated. Selection bias also arises in motivation studies. Individuals responding to financial incentives will tend to work in firms offering them. Studies of payment-by-results systems in one firm may overestimate overall economic potential of introducing such schemes. The selection bias will increase, the more alternative employment and educational opportunities there are. Adaptation will also weaken observed effects. People adapt to different diseases by choice of occupation or by making special efforts to compensate.

(b) Motivation

Both individual worker, and firm level data, can be used to study motivation. At the level of a firm, time series and experimental evidence seem most able to control for firm specific factors. At the individual worker level, any of cross section, time series, or experimental evidence might be appropriate.

There is a large and growing literature on psychological factors at work, and also on worker attitudes on job satisfaction and their determinants. While increased job satisfaction may be an end in its own right, it is of interest how satisfaction or attitudes can affect productivity. Linking current sociological and psychological research in this area to economic effects, might prove fruitful. However, this is a somewhat complicated area, as job satisfaction has not been found to be clearly related to productivity. (Ribeaux and Poppleton (1978) cite Vroom, and Brayfield and Crockett on this.)
There is evidence that motivational factors are important in performance, although there is disagreement on the different effects of financial motivation, intrinsic job content, agreeable social surroundings and so on. This may be worth investigation, especially as non-financial motivating factors may be used at relatively low cost, and financial motivation may be profitable.

Similar studies might fully be extended to developing countries, where the main research on motivation has so far been on material incentives. Perhaps for many developing countries, levels of income are sufficiently low that material incentives vastly outweigh other motivating factors. It seems more likely, however, that relative lack of studies of attitudes and motivation comes from the difficulty of conceptualizing such research in countries with different perceived attitudes and needs.

A difficulty with motivation studies is that of measuring the inputs which increase productivity, and of controlling for other factors. Studies of a firm over time are likely to have motivation effects confounded by technical change, learning by doing, management changes, and so on. For a firm it is difficult to find another firm to act as a control, or to identify enough of the factors necessary to control. Also at the firm level, experimental evidence would have to be natural experiments, e.g. comparing firms which choose to implement incentive schemes or job enrichment. In this case there is likely to be selection bias, i.e. the firms implementing such schemes may have atypically rapid growing productivity anyway, or else alternately face sufficient problems or have a sufficiently large potential productivity gain as to necessitate managerial action. Even if firm-level factors are identified and measured, they may be difficult to replicate, and especially transfer across countries. Successes and failures of multinational companies in this respect would be a very interesting area to study; to what extent are they forced to change management styles and even production methods to conform to local attitudes.

It would seem easier to perform controlled experiments at the individual worker level than at firm level, and eliminate firm specific effects. It is also possible to use cross section data comparing workers within one firm. The problem here would seem to be able to measure attitude and motivation in an interpersonally comparable way.

(c) Management

Between the broad national comparisons of micro level economic performance and the analysis of the characteristics and output of individual workers there is the very important middle ground of firm and industry studies. Here most of the research on management, industrial relations and work organization must lie. But it is far from exhausted as a medium for more conventional economic research. Relatively little work has been done to compare total factor productivities of firms across countries, within one industry. Using total factor productivity eliminates the problem of different factor ratios and techniques. This, however, requires considerable data. Pack is
apparently continuing earlier (1979) work, and a UNIDO data set currently being collected may be of use. There is also apparently an intention to extend the Jorgenson and Nishimizu (1979) study of US and Japan to examine the causes of differences in total factor productivity. This type of study could possibly use Farrell's technique for measuring level and two kinds of efficiency.

An alternate route might be to choose firms with similar technologies. Pratten's (1975a) method of using paired firms in two countries at similar levels of development might be fruitfully extended. Another method might be to compare multinational subsidiaries in different countries, as done in the Central Policy Review Staff Study of the British car industry. There is some evidence that technology is adapted to the host country, but the technique might again be used more widely for countries at similar levels of development.

Firm-level studies such as Cole et al. (1969), or Lamyai et al. would seem to provide valuable information on management ability to solve the problem of appropriate technique, for a single project.

Conclusion

The World Development Report 1980 points out that the reason for the much more rapid growth of some East Asian developing economies than others of similar income level, is not simply that they have invested a higher proportion of their output. They have also managed to squeeze as much as half an extra unit of annual output from an extra unit of capital. Part of this comes from paying considerable attention to the law of comparative advantage. Much also comes from high levels of human resource development, as discussed extensively in the World Development Report. Although as we have seen in this paper, our knowledge of linking expenditures on human development directly to gains in productivity is still far from satisfactory, the evidence suggests that in most developing countries the returns to such investment remain high. Research here needs to be primarily at a microeconomic level and to pay special attention to understanding the mechanisms by which human development raises productivity in particular circumstances.

But the findings of this paper also stress how inefficiently the world uses its productive resources. A great deal more could be produced, and higher incomes earned, with virtually no investment, human or physical. The slow pace of production lines in the British car industry, largely attributable to work practices and poor industrial relations, may be a peculiarly pathological case, but the many ad hoc studies of the productivity gains from work reorganization, changes in incentive policies, attempts to raise the quality of working life etc. suggest that it is far from unique. Most of this sort of research is in developed countries; but very casual observation, and perusal of the literature on industrial problems, in developing countries, give no
reason to suppose the situation is better there. Indeed in many highly pro-
tected sectors, it is probably worse. "Getting prices right" may be a step
towards a solution, but it is surely not the whole answer. Pinpointing the
key elements of Japanese and Korean economic success raises questions in
fields of research reveal that economists would consider maddeningly impre-
cise - questions of child upbringing, moral education, social cohesion, and
sense of participation are bound to enter in. Translating such analysis into
policy recommendations to make to, say, the Government of Malawi appears to be
a daunting task. Economists may feel that they have little to offer, but it
needs to be attempted.
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